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Samuel

4 Sheets—Sheet 1.

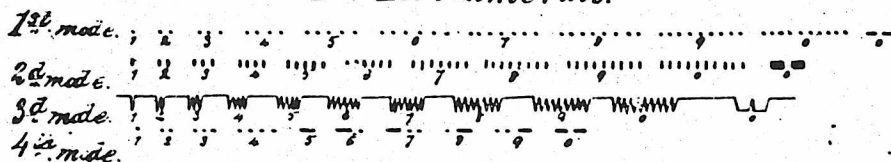
S. F. B. MORSE.
ELECTROMAGNETIC TELEGRAPH.

No. 1,647.

Patented June 20, 1840

Example 1st

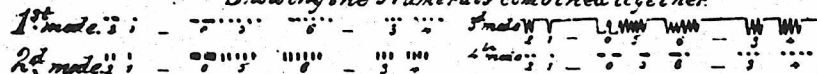
1st For Numerals.



Example 2^d

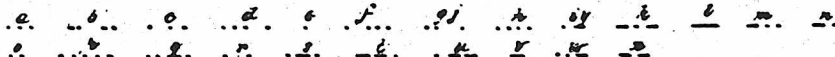
For Compound Numerals.

Showing the Numerals combined together



Example 3.

2^d For Letters.



The System of Type.

Fig. 1st Example 4th 1st For Numerals.

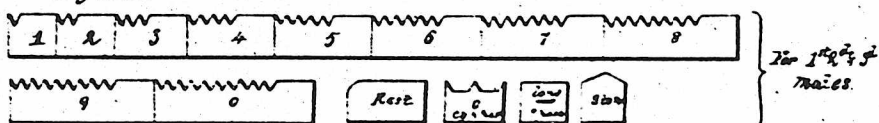
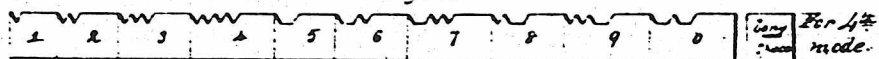


Fig. 2^d



Example 5th 2^d For Letters.

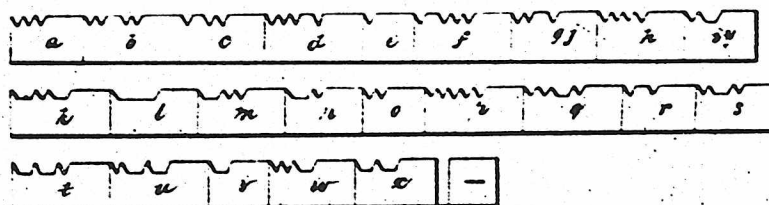


Fig. 1.



Example 6th



Fig. 2.

Fig. 3.



UNITED STATES PATENT OFFICE.

SAMUEL F. B. MORSE, OF NEW YORK, N. Y.

IMPROVEMENT IN THE MODE OF COMMUNICATING INFORMATION BY SIGNALS BY THE APPLICATION OF ELECTRO-MAGNETISM.

Specification forming part of Letters Patent No. 1,647, dated June 20, 1847.

To all whom it may concern:

Be it known that I, the undersigned, SAMUEL F. B. MORSE, of the city, county, and State of New York, have invented a new and useful machine and system of signs for transmitting intelligence between distant points by the means of a new application and effect of electro-magnetism in producing sounds and signs, or either, and also for recording permanently by the same means and application and effect of electro-magnetism any signs thus produced and representing intelligence transmitted, as before named, between distant points; and I declare that I am the inventor of the "American Electro-Magnetic Telegraph," of which the following is a full and exact description, to wit:

It consists of the following parts: first, of a circuit of electric or galvanic conductors from any generator of electricity or galvanism, and of electro-magnets at any one or more points in said circuit; second, a system of signs by which numerals and words represented by numerals, and thereby sentences of words as well as of numerals, and letters of any extent and combination of each, are communicated to any one or more points in the before-described circuit; third, a set of type adapted to regulate the communication of the above-mentioned signs, also cases for convenient keeping of the type, and rules in which to set and use the type; fourth, an apparatus called the "straight port-rule," and another called the "circular port-rule," each of which regulates the movement of the type when in use, and also that of the signal-lever; fifth, a signal-lever which breaks and connects the circuit of conductors; sixth, a register which records permanently the signs communicated at any desired points in the circuit; seventh, a dictionary or vocabulary of words, to which are prefixed numerals for the uses hereinafter described; eighth, modes of laying the circuit of conductors.

The circuit of conductors may be made of any metal—such as copper or iron wire or strips of copper or iron, or of cord or twine, or other substances—gilt, silvered, or covered with any thin metal leaf properly insulated and in the ground, or through or beneath the water, or through the air. By causing an electric or galvanic current to pass through the circuit of conductors laid as aforesaid by means of any

generator of electricity or galvanism to one or more electro-magnets placed at any point or points in said circuit, the magnetic power thus concentrated in such magnet or magnets is used for the purposes of producing sounds and visible signs, and for permanently recording the latter at any and each of said points, at the pleasure of the operator, and in the manner hereinafter described—that is to say, by using the system of signs which is formed of the following parts and variations, viz:

Signs of numerals consist, first, of ten dots or punctures, made in measured distances of equal extent from each other, upon paper or any substitute for paper, and in print or corresponding with the numeral desired to be represented. Thus one dot or puncture for the numeral 1, two dots or punctures for the numeral 2, three of the same for 3, four for 4, five for 5, six for 6, seven for 7, eight for 8, nine for 9, and ten for 0, as particularly represented on the annexed drawing, marked Example 1, Mode 1, in which is also included a second character, to represent a cipher, if preferred.

Signs of numerals consist, secondly, of marks made as in the case of dots, and particularly represented on the annexed drawing, marked Example 1, Mode 2.

Signs of numerals consist, thirdly, of characters drawn at measured distances in the shape of the teeth of a common saw by the use of a pencil or any instrument for marking. The points corresponding to the teeth of a saw are in number to correspond with the numeral desired to be represented, as in the case of dots or marks in the other modes described, and as particularly represented in the annexed drawing, marked Example 1, Mode 3.

Signs of numerals consist, fourthly, of dots and lines separately and conjunctively used as follows, the numerals 1, 2, 3, and 4 being represented by dots, as in Mode 1, first given above: The numeral 5 is represented by a line equal in length to the space between the two dots of any other numeral; 6 is represented by the addition of a dot to the line representing 5; 7 is represented by the addition of two dots to said line; 8 is represented by prefixing a dot to said line; 9 is represented by two dots prefixed to said line; and 0 is represented by two lines, each of the length of said line that represents

the number 5. Said signs are particularly set forth in the annexed drawings, marked Example 1, Mode 4.

Either of said modes are to be used as may be preferred or desired and in the method hereinafter described.

The sign of a distinct numeral or of a compound numeral when used in a sentence of words or of numerals consists of a distance or space of separation between the characters of greater extent than the distance used in separating the characters that compose any such distinct or compound numeral. An illustration of this sign is particularly exhibited in the annexed drawing, marked Example 2.

Signs of letters consist in variations of the dots, marks, and dots and lines, and spaces of separation of the same formation as compose the signs of numerals, varied and combined differently to represent the letters of the alphabet, in the manner particularly illustrated and represented in the annexed drawing, marked Example 3.

The sign of a distinct letter, or of distinct words when used in a sentence, is the same as that used in regard to numerals and described above.

Signs of words, and even of set phrases or sentences, may be adopted for use and communication in like manner under various forms, as convenience may suggest.

The type for producing the signs of numerals consist, first, of fourteen pieces or plates of thin metal—such as type-metal, brass, iron, or like substances—with teeth or indentations upon one side or edge of ten of said type, corresponding in number to the dots or punctures or marks requisite to constitute the numerals, respectively, heretofore described in the system of signs, and having also a space left upon the side or edge of each type, at one end thereof, without teeth or indentations, corresponding in length with the distance or separation desired between each sign of a numeral. Another of said type has two indentations, forming thereby three teeth only, and without any space at either end, to correspond with the size of a cipher, as heretofore described by reference to Example 1, Modes 1, 2, 3, of drawings in said system of signs. One other of said type is without any indentation on its side or edge, and being in length to correspond with the distance or separation desired between distinct or compound numerals, and with the sign heretofore described for that purpose. One of the remaining two of said type is formed with one corner of it beveled, (system of type, Example 4, Fig. 1,) and is called a "rest;" and the other is in a pointed form and called a "stop."

Each of said type is particularly delineated on the annexed drawing, marked Example 4, Fig. 1, and numbered or labeled in accordance with the purpose for which they are designed respectively, and are used in like manner for producing each of the several signs of numerals heretofore described in the system of signs.

The type for producing the signs of numerals

consist, secondly, of five pieces or plates of metal, first described above, four of which are the same as are numbered 1, 2, 3, and 4 in the annexed drawing, marked Example 4, Fig. 1, and the fifth one being the same as is denominated in the same example "the long space," and heretofore alluded to also, of six other pieces or plates of said metal, varied in indentations and teeth and spaces, as represented on the annexed drawing, marked Example 4, Fig. 2, to produce signs of the denominations described in the fourth mode of the before-mentioned system of signs, Example 1.

The type for producing the signs of letters are of the same denomination with those used in producing signs of numerals, and only varied in form from one to twenty-three, as exhibited in the annexed drawing, marked Example 5.

The type for producing both signs of numerals and signs of letters are adapted for use to either a straight rule, called the "straight port-rule," and are in that case made straight lengthwise, as described in the drawings annexed, and heretofore referred to in Example 3, or to a circular port-rule, in which case they are lengthwise circular or formed into sections of a circle, as represented in the drawings annexed, marked Example 6, Figs. 2 and 3, and as will be further understood by the descriptions hereinafter contained of the straight and circular port-rules. On the under side of the type for the circular port-rule (which type are of greater thickness than those for the straight port-rule) is a groove, a system of type, Example 6, A in Figs. 1 and 2, about midway of their width, and in depth about half the thickness aforesaid, and extending from the space ends, as B, Example 6, Fig. 3—that is, the ends without indentations—of said type, along the length, and conforming to the curve thereof, to a point, D D, equal in distance from the opposite ends to half the width of the pointed teeth cut upon their edges. For a delineation of these type reference is made to sections thereof in Figs. 1 and 3 upon the annexed drawings, marked Example 6.

The type-cases are wood or of any other material, with small compartments of the exact length of the type, for greater convenience in distributing, and resembling those in common use among printers.

The type-rules are of wood or metal or other material that may be preferred, and about three feet in length, with a groove, into which the type, when used, are placed. On the under side of each type rule are cogs, by which they are adapted to a pinion-wheel having corresponding cogs and forming part of a port-rule. The type-rule in use is moved onward as motion is given to the said wheel. A delineation of the type-rule is contained in the annexed drawing, marked Example 7.

The straight port-rule consists of a pinion-wheel, (before mentioned,) turned by a hand-crank attached to a horizontal screw that plays into the cogs of the pinion-wheel, as the latter do into the cogs of the type rule, or by any

1
6
4
7

1
6
4
7

other power, in any of the well-known methods of mechanism. It is connected with a railway or groove, in and by which the type-rule, from the motion imparted to it by said wheel, is conveyed in a direct line beneath a lever that breaks and connects the galvanic circuit in the manner hereinafter mentioned. A delineation of said wheel, crank, and screw is contained in the drawings hereto annexed, marked Example 8, Figs. 1, 2, 3.

The circular port-rule is a substitute, when preferred, for both the type-rule and the straight port-rule, and consists of a horizontal or inclined wheel, Example 9, Fig. 1, A, of any convenient diameter, of wood or metal, having its axis connected on the under side of the wheel with a pinion-wheel, K, and as in the case of the straight port-rule. It is moved by the motion of the pinion-wheel, as is the type-rule in the former description. On the entire circumference of said horizontal or inclined wheel, and upon its upper surface, is a shoulder or cavity, *a*, Figs. 1, 2, corresponding in depth with the thickness of the type used, and in width, *b*, equal to that of the type, exclusive of their teeth or indentations. Near the outer edge of the surface of said shoulder or cavity are cogs, *c*, throughout the circumference of the wheel, projecting upward at a distance from each other equal to one-half of the width of the teeth or indentations of the type, and otherwise corresponding in size to the width and depth of the groove D D, Fig. 4, in the under side of the circular type before described and illustrated by reference to Example 6, Figs. 1 and 3. Directly over said shoulder or cavity and cogs, and at one or more points on the circumference of said wheel, is extended, from a fixture outside of the orbit of the wheel, a stationary type-feeder, E, Fig. 1, formed of one end, *e*, and one side, *f*, perpendicular of tin or brass plate or other substance, and of interior size and shape to receive any number of the type which are therein deposited, with their indentations projecting outward, as in Fig. 2, and their grooves downward, as in Fig. 4. Said type-feeder is so suspended from its fixture F over the shoulder or cavity of the wheel A, before described, as to admit of the passage under it of said wheel in its circuit as near the bottom of the feeder as practicable without coming in contact therewith. The type deposited in the feeder, as before mentioned, form a perpendicular column, as in Fig. 2, the lower type of which rests upon the surface of the before-named shoulder of the wheel *b*, Fig. 2, and the cog of the wheel, projecting upward, enters the groove D D, Fig. 4, of the type hereinbefore described.

The operation of said circular port-rule in regulating the movement of the type in use is as follows: When the wheel A is set in motion the type resting immediately upon the shoulder of the wheel in the manner mentioned above, as in Fig. 2, is carried forward on the curvature of the wheel from beneath the column of type resting upon it in the stationary

type-feeder by means of one of the before-named cogs coming in contact with that point D, Fig. 3, Example 6, in the groove of the type hereinbefore described as forming the termination of said groove, and which is particularly delineated at the points D D in the annexed drawing, marked Example 6, Fig. 3. As by said process the lower type in the column that is held by the stationary feeder is carried forward and removed, the next type settles immediately upon the shoulder of the wheel, and, after the manner of the removed type, is brought in contact with another cog of said shoulder within the groove of the type, and thence carried forward from beneath the incumbent column, as was its predecessor. Then follows consecutively in the same method each type deposited within the feeder so long as the wheel is kept in motion. The deposit of the type in the stationary feeder is regulated by the order in which the letters or numerals, or words they represent, are designed to be communicated at any distant point or points. After the type are respectively carried forward on the curvature of the wheel in the manner stated above beyond the point where they are acted upon by the signal-lever, as is hereinafter described, they are lifted, each in its turn, from the shoulder of the wheel A and cast off into a box or pocket, G, below the wheel by means of a slender shaft or spindle, H, made of any metal, and resembling in form a common plowshare, extending downward from a fixture, *a*, placed outside of the wheel, into a groove, K, within the before-named shoulder of said wheel A, and on the inner side of the cogs *c*, already described. By means of said groove the downward point of said shaft or spindle H is brought within the curvature and below the surface of said shoulder *b*, Fig. 2, and consequently under the approaching end of the type, so that each type successively, as it is carried forward on said curvature in the manner before described is lifted from the shoulder and forced upward on the inclined shaft or spindle by the type in contact with it at the other end, until turned off into the before-named box or pocket G below, ready for a redistribution.

For a more particular delineation of the several parts of said circular port-rule reference is made to the annexed drawings, marked Example 9, Figs. 1 and 2.

The signal-lever, Example 9, Fig. 3, consists, first, for use with the straight port-rule, (Example 8, Fig. 1, A,) of a strip of wood of any length from six to twenty-four inches, resting upon a pivot, *a*, or in a notched pillar formed into a fulcrum by a metal pin, *a*, passing through it and the lever. At one end of the lever a metallic wire, bent to a semicircular or half-square form, as at A, or resembling the prongs of a fork distended, is attached by its center, as described in the annexed drawings, Example 8, at the point marked A. Between said end of the lever and the fulcrum *a*, and near the latter, on the under side of the lever A, is inserted a metallic tooth or cog, *b*, curved

on the side nearest to the fulcrum, and in other respects corresponding to the tooth or indentations upon the type already described. On the opposite extremity of the lever is a small weight, C, to balance or offset in part when needed, the weight of the lever on the opposite side of the fulcrum. The lever thus formed is stationed directly over the railway or groove D D, heretofore described as forming a connected part of the straight port-rule. The movement of the type rule brings the tooth of each type therein set in contact with the tooth or cog of the lever, and thereby forces the lever upward until the point *a* of the two teeth in contact have passed each other, when the lever again descends as the teeth of the type proceed onward from the tooth of the lever. This operation is repeated as frequently as the teeth of the type are brought in contact with the tooth of the lever. By thus forcing the said lever upward and downward the ends of the semicircular or pronged wire are made alternately to rise from and fall into two small cups or vessels of mercury, E, E, in each of which is an end or termination of the metallic circuit-conductors first described above. This termination of the metallic circuit in the two cups or vessels breaks and limits the current of electricity or galvanism through the circuit; but a connection of the circuit is effected or restored by the falling of the two ends of the pronged wire A, attached to said lever, into the two cups, connecting the one cup with the other in that way. By the rising of the lever, and consequently the wire upon its end, from its connection with said cups said circuit is in like manner again broken and the current of electricity or galvanism destroyed. To effect at pleasure these two purposes of breaking and connecting said circuit is the design of said motion that is imparted in the before-mentioned manner to said lever, and to regulate this motion and reduce it to the system of intelligible signs before described is the design and use of the variations in the form of the type, also before described. A plate of copper, silver, or other conductor connected with the broken parts of said circuit of conductors, and receiving the contact of the wire attached to said lever, may be substituted, if preferred, for said cups of mercury. For a particular delineation of the several parts of said lever reference is made to the annexed drawing, marked Example 9.

The signal-lever consists, secondly, for use with the circular port-rule, (Example 9, Fig. 3,) of a strip of wood, G, with a metallic wire, A, at one end, of the form and for the purposes of the lever already described above. It turns on a pivot or fulcrum, *a*, placed either near the middle or in the end of the lever. At the end of the lever, at C, opposite to the metallic wire A, an elbow, *e*, is formed on a right angle with the main lever, and extending downward from the level with the pivot or fulcrum sufficiently for a metallic tooth, H, in the end thereof, corresponding with the teeth or indentations of

the type already described, to press against the type projecting from the shoulder or cavity of the wheel A, Fig. 1, that forms the circular port-rule before described. Said wheel is placed beneath the said lever, as seen at G, Fig. 1, in a position to be reached by the extremity or tooth H of the arm of the lever just mentioned. The tooth H in the arm of the lever is kept in constant contact with the type of the circular port-rule by the pressure of a spring, B, upon it, as described in the annexed drawing, marked Example 9, at B, Figs. 1 and 3 in the same example exhibit sections of the said lever. The action thus produced by the contact of the teeth of the type in the port-rule when said wheel is in motion with the tooth in the arm of the lever lifts up and drops down the opposite extremity A of said lever having the metallic wire upon it as the tooth of said lever passes into or out of the indentations of the type, and in the same manner and to the same effect as the first described lever to rise and fall, and accordingly breaks and closes the circuit of conductors, as in the former instance. In the use of this circular port-rule and its appropriate lever (Fig. 3) type may be used having the points of their teeth and their indentations shaped as counterparts or reverses to those delineated in the annexed drawings, heretofore referred to and marked Examples 4, 5, and 6, and thereby the forms of the recorded signs will be changed in a corresponding manner.

The register consists—

First, of a lever of the shape of the lever connected with the circular port-rule above described, and is delineated in the annexed drawing, marked Example 10, Figs. 1, 2, and 4, at A. Said lever A operates upon a fulcrum, *a*, that passes through the end that forms the elbow *a*, upon the lower extremity of which, and facing an electro-magnet, is attached the armature of a magnet, *f*. In the other extreme of the lever, at B, is inserted one or more pencils, fountain-pens, printing-wheel, or other marking-instruments, as may be seen in the Fig. 4 of example last mentioned at letter B. The magnet is at letter C in the same figure.

Secondly, of a cylinder or barrel of metal or wood and covered with cloth or yielding coating, to turn upon an axis, and occupying a position directly beneath the pencil, fountain-pen, printing-wheel, or other marking-instrument, to be used as exhibited in the last-mentioned example of drawing, Fig. 4, D. Two rollers, marked *b* and *b* in said figure of drawings, are connected with said cylinder, on the opposite curvatures thereof, and being connected with each other by two narrow bands of tape passing over and beneath each, near the ends thereof, and over the intervening surface of the cylinder, in a manner to cause a friction of the bands of tape upon the latter when in motion, as delineated in the last-mentioned example, Fig. 4, at points marked *e* and *e*. The distance between said bands of tape on the rollers is such as to admit of the pencil or other

marking-instrument in the lever to drop upon the intervening space of the cylinder. Near by said cylinder is a spool to turn on an axis, and marked *d* in the said figure, to receive any desired length of paper or other substance formed into slips or a continuous ribbon, and for the purpose of receiving a record of the signs of intelligence communicated. When the register is in motion, one end of the paper on said spool being inserted between the under surfaces of said two rollers, under the strips of tape that connect them and the cylinder, it is drawn by the friction or pressure thus caused upon it forward from said spool gradually and passed over said cylinder, and is thence deposited in a box on the opposite side or is cut off at any desired length as it passes from the cylinder and rollers.

Thirdly, of an alarm-bell, *A*, Example 10, Fig. 5, which is struck by means of a lever-hammer, *B*, that is acted upon by a movable cog, *b*, placed upon an axis or pin, *b*, that confines it in the lower extremity of a pendulum-lever, (marked *E* in Fig. 5 of Example 10) having an armature of a magnet attached to it at *d* and acted upon by an electro-magnet, *a*, placed near it and the before-named magnet, and in the same circuit of conductors with the latter. Said cog *b* moves in a quarter-circle only, as the motion of said arm of the lever passes backward and forward in the act of recording, as hereinafter described. When forced into a horizontal position in said quarter-circle it ceases to act upon the hammer; but when moved from a perpendicular position it presses upon the projection in the end of the hammer, causing the opposite end of the hammer to be raised, from which elevation it again falls upon a stationary bell, *A*, as soon as said cog reaches a horizontal position, and ceases, as before mentioned, to press upon the hammer. Thus a notice by sound or an alarm is given at the point to which intelligence is to be communicated as soon as the register begins to act, and such sound may be continued or not, at pleasure, for the purpose mentioned, or for any other uses, as the hammer shall be suspended or not from contact with the bell or with any number of bells that may be employed. Fig. 5 of said example, marked 10 in the annexed drawings, represents sections of said hammer and bell.

Said several parts of the register are set in motion by the communication to or action upon the before-named armature of a magnet attached to the lever of the register, of the electric or galvanic current in the circuit of conductors, and from an electro-magnet in said circuit, as before described, stationed near the said armature. As said armature is drawn or attracted from its stationary and horizontal position toward the said magnet, when the latter is charged from the circuit of conductors, said lever is turned upon its fulcrum, and the opposite end thereof necessarily descends and brings the pen or marking-in-

strument which it contains in contact with the paper or other substance on the revolving cylinder directly beneath it. As said armature ceases to be thus drawn or attracted by said magnet, as is the case as soon as said magnet ceases to be charged from the circuit of conductors, or as the current in said circuit is broken in the manner hereinafter described, the said armature is forced back by its own specific gravity or by a spring or weight, as may be needed, to its former position, and the pen or marking-instrument in the opposite end of the lever is again raised from its contact with the paper or other substance on the before-named revolving cylinder. This same action is communicated simultaneously from the same circuit of conductors to as many registers as there are corresponding magnets provided within any circuit and at any desired distances from each other.

The cylinder and its two associate rollers are set in motion simultaneously with the first motion of the lever by the withdrawal of a small wire or spindle, *g*, Example 10, Figs. 2 and 3, from beneath one branch of a fly-wheel, *k*, that forms a part of the clock machinery hereinafter named. Said wire *g* is withdrawn by the action upon said wire of a small electro-magnet, *a*, Figs. 2 and 3, stationed in the circuit and near the large magnet before named, as delineated in Fig. 5 of Example 10. Said cylinder and rollers are subsequently kept in motion by a train of wheels similar to common clock-wheels, as in Figs. 2 and 3, acted upon by a weight, raised as occasion may require by a hand-crank, and their motion is regulated by the same wheels to correspond with the action of the registering-pen or marking-instrument. Said train is represented in Figs. 1, 2, and 3 of Example 10.

The electro-magnet thus used is made in any of the usual modes, such as winding insulated copper wire, or strips of copper, or tin-foil, or other metal around a bar of soft iron, either straight or bent into a circular form, and having the two extremities of the coils connected with the circuit of conductors, so that the coils around the magnet make part of the circuit.

To extend more effectually the length of any desired circuit of conductors, and to perpetuate the power of the electric or galvanic current equally throughout the same, I adopt the following mode, and also for connecting and using any desired number of additional and intervening batteries or generators of said current, and for connecting progressively any number of consecutive circuits, viz: Place at any point in a circuit an electro-magnet of the denomination already described, with an armature upon a lever of the form and structure, and in the position of that used at the register to hold and operate the marking-instrument, with only a substitution therein for said marking-instrument of a forked wire, *A*, Example 9, Fig. 3, like that upon the end of the signal-lever heretofore described. Directly beneath the latter

wire place two cups of mercury, *E E*, or two metallic plates joined to terminations of a circuit leading from the first or additional battery or generator of said circuit, in the same manner as they are to be provided in the first circuit of conductors at the points where the cups of mercury are hereinbefore described. As the current in the first circuit acts upon the magnet thus provided the armature thereof and lever are thereby moved to dip the forked wire *A* into the cups of the second circuit, as in the circuit first described. This operation instantly connects the break in said second circuit, and thus produces an additional and original power or current of electricity or galvanism from the battery of said second circuit to the magnet or magnets placed at any one or more points in such circuit, to be broken at pleasure, as in the first circuit; and from thence, by the same operation, the same results may again be repeated, extending and breaking at pleasure such current through yet another and another circuit, *ad infinitum*, and with as many intervening registers for simultaneous action as may be desired, and at any distances from each other.

The dictionary or vocabulary consists of words alphabetically arranged and regularly numbered, beginning with the letters of the alphabet, so that each word in the language has its telegraphic number, and is designated at pleasure through the signs of numerals.

The modes which I propose of insulating the wires or other metal for conductors act of laying the circuits are various. The wires may be insulated by winding each wire with silk, cotton, wax, or hemp, and then dipping them into a solution of caoutchouc, or into a solution of shellac, or into pitch or resin and caoutchouc. They may be laid through the air, inclosed above the ground, in the ground, or in the water. When through the air they may be insulated by a covering that shall protect them from the weather—such as cotton, flax, or hemp—and dipped into any solution which is a non-conductor, and elevated upon pillars. When inclosed above the ground they may be laid in tubes of iron or lead, and these, again, may be inclosed in wood, if desirable. When laid in the ground they may be inclosed in iron, leaden, wooden, or earthen tubes, and buried beneath the surface. Across rivers the circuit may be carried beneath the bridges, or, where there are no bridges, inclosed in lead or iron and sunk at the bottom, or stretched across, where the banks are high, upon pillars elevated on each side of the river.

What I claim as my invention, and desire to secure by Letters Patent, is as follows:

1. The formation and arrangement of the several parts of mechanism constituting the type-rule, the straight post-rule, the circular post-rule, the two signal-levers, and the register-lever and alarm-lever, with its hammer, as combining respectively with each of said

levers one or more armatures of an electro-magnet, and as said parts are severally described in the foregoing specification.

2. The combination of the mechanism constituting the recording cylinder and the accompanying rollers and train-wheels with the formation and arrangement of the several parts of mechanism, the formation and arrangement of which are claimed as above and as described in the foregoing specification.

3. The system, formation, and arrangement of type and of signs for transmitting intelligence between distant points by the application of electro-magnetism and metallic conductors combine with mechanism described in the foregoing specification.

4. The mode and process of breaking and connecting by mechanism currents of electricity or galvanism in any circuit of metallic conductors, as described in the foregoing specification.

5. The mode and process of propelling and connecting currents of electricity or galvanism in and through any desired number of circuits of metallic conductors from any known generator of electricity or galvanism, as described in the foregoing specification.

6. The application of electro magnets by means of one or more circuits of metallic conductors from any known generator of electricity or galvanism to the several levers in the machinery described in the foregoing specification, for the purpose of imparting motion to said levers and operating said machinery, and for transmitting by signs and sounds intelligence between distant points and simultaneously to different points.

7. The mode and process of recording or marking permanently signs of intelligence transmitted between distant points and simultaneously to different points by the application and use of electro-magnetism or galvanism, as described in the foregoing specification.

8. The combination and arrangement of electro-magnets in one or more circuits of metallic conductors with armatures of magnets for transmitting intelligence by signs and sounds, or either, between distant points and to different points simultaneously.

9. The combination and mutual adaptation of the several parts of the mechanism and system of type and of signs with, and to the dictionary or vocabulary of words, as described in the foregoing specification.

In testimony whereof I, the said SAMUEL F. B. MORSE, hereto subscribe my name, in the presence of the witnesses whose names are hereto subscribed, on the 17th day of April, A. D. 1845.

SAML. F. B. MORSE.

Witnesses:

B. B. FRENCH,
CHARLES MONROE.

THE
ELECTRO-MAGNETIC TELEGRAPH:

WITH AN

HISTORICAL ACCOUNT

OF ITS

RISE, PROGRESS, AND PRESENT CONDITION.

ALSO,

PRACTICAL SUGGESTIONS IN REGARD TO INSULATION,

AND

PROTECTION FROM THE EFFECTS OF LIGHTNING.

TOGETHER WITH AN

APPENDIX,

CONTAINING

SEVERAL IMPORTANT TELEGRAPHIC DECISIONS AND LAWS.

BY

LAURENCE TURNBULL, M. D.,

LECTURER ON TECHNICAL CHEMISTRY AT THE FRANKLIN INSTITUTE OF THE STATE OF PENNSYLVANIA.

Second Edition, Revised and Improved.

ILLUSTRATED BY NUMEROUS ENGRAVINGS.

PHILADELPHIA:

A. HART, LATE CAREY AND HART.

1853.

foot of the stand of the spy-glass *R*, that the image of the parts of the scale can be seen in the mirror through the spy-glass.

The apparatus contrived by Gauss for the rapid change of the direction of the current was somewhat complicated; but any other simple *commutator* can be used for the same purpose.

The following is the mode of using this telegraph: At the station from which a communication is to be sent, the inductor *M*, Fig. 21, is suddenly drawn off, and again, without turning it round, thrust down upon the magnet pole *B*, by which means two induction currents of opposite directions are passed through the conducting wire.

By means of the first current, the magnet in the observing apparatus, Fig. 22, at the other station, through the action of the multiplier's coils, is made to diverge in a determined direction, for example, to the right. By means of the second current in the opposite direction it is immediately stopped, so that the magnet can make no farther *excursions*, but only, in consequence of the two opposite currents, makes a little lively vibration to one side, and then immediately remains quite still.

These small motions of the magnet are observed through the spy-glass *R*, Fig. 22, in the mirror *N*.

In a state of rest, the image of the null point of the scale, *m m*, is visible through the spy-glass; by the motion of the magnet the mirror is also moved, and reflects to the spy-glass another part of the scale. In this manner the smallest motion of the magnet is perceptible by the spy-glass.

Accordingly as the commutator (which is directly attached to the inductor) is fixed, the *first* induction current passes in one or the opposite direction through the conducting wire—and therefore, by a sudden drawing off and thrusting down of the reel *B*, Fig. 21, a magnetic vibration to the right or left at the other station can be produced at pleasure.

By an ingenious combination of several magnetic motions, to form a signal, Gauss and Weber were able to make all requisite signs (letters and ciphers) with these two *motions* (*first blows*).

The following are the alphabetical signs as arranged:—

<i>r</i>	=	<i>a</i>	<i>rrr</i>	=	<i>e k</i>	<i>lrl</i>	=	<i>m</i>	<i>lrrr</i>	=	<i>w</i>	<i>llrr</i>	=	<i>4</i>
<i>l</i>	=	<i>e</i>	<i>rll</i>	=	<i>d</i>	<i>rlr</i>	=	<i>n</i>	<i>rrll</i>	=	<i>z</i>	<i>lllr</i>	=	<i>5</i>
<i>rr</i>	=	<i>i</i>	<i>rlr</i>	=	<i>f v</i>	<i>rrrr</i>	=	<i>p</i>	<i>rlrl</i>	=	<i>o</i>	<i>llrl</i>	=	<i>6</i>
<i>rl</i>	=	<i>u</i>	<i>lrr</i>	=	<i>g</i>	<i>rrrl</i>	=	<i>r</i>	<i>rlrl</i>	=	<i>1</i>	<i>lrll</i>	=	<i>7</i>
<i>lr</i>	=	<i>u</i>	<i>lll</i>	=	<i>h</i>	<i>rrrl</i>	=	<i>s</i>	<i>lrrl</i>	=	<i>2</i>	<i>rlrl</i>	=	<i>8</i>
<i>ll</i>	=	<i>b</i>	<i>llr</i>	=	<i>l</i>	<i>rlrr</i>	=	<i>t</i>	<i>lrlr</i>	=	<i>3</i>	<i>llll</i>	=	<i>9</i>

The variations of the magnetic needle signify a letter; *l* denotes a variation to the left, and *r* to the right, and by the combined deflection of the needle, words and sentences may be transmitted.

Experiments of Messrs. Taquin and Ettieyhausen.

Messrs. Taquin and Ettieyhausen made experiments with a telegraphic line over two streets in Vienna, 1836. The wires passed through the air and under the ground of the Botanic Garden.—*Polytechnic Centra. Journal*, 1830; *Vail Electro-Magnetic Telegraph*, p. 189.

MORSE'S ELECTRO-MAGNETIC TELEGRAPH.

In the latter part of the year 1832, Samuel F. B. Morse, an ingenious American artist, while on a voyage homeward from Europe, conceived the idea of an electric or electro-chemical telegraph, and devised a system of signs for letters, to be marked by the breaking and closing of the electric or galvanic current.

Dr. C. T. Jackson, of Boston, a fellow-passenger, well versed in the science of chemistry and electricity, and having witnessed numerous experiments during a recent visit to Paris, afforded him considerable assistance.

The following is a brief account of the methods proposed:—

1st. That electricity might be made visible in any part of the circuit by dividing the wire, when a spark would be seen at the intersection.

2d. That it could be made to perforate paper if interposed between the disconnected wires.

3d. Saline compounds might be decomposed, so as to produce colors on paper.

The 2d and 3d projects were adopted for future trial, since they would furnish permanent records. The saline substances mentioned, were the acetate and carbonate of lead, which, when decomposed by the galvanic current, left black marks on the prepared paper; again, turmeric paper, moistened in a solution of sulphate of soda, left brown marks on the passage of the current, produced by the disengaged alkali. Platina points were also proposed to effect the changes in color.

Mr. Morse experimented for some time after arriving in New York, independent, however, of Dr. Jackson. While on board the *Sully*, Dr. Jackson doubtless materially aided Mr. Morse in his conception of the electric telegraph, though they do not appear to have had any subsequent connection, nor was the instrument they devised brought into practical use.

From a careful examination of all the evidence given by the passengers on board of the packet ship *Sully*, the telegraph devised by Morse and Jackson was not an electro-magnetic telegraph, but an electric or electro-chemical telegraph (see letters of Dr. Jackson to Mr. Morse, and Mr. Kendall's pamphlet, and letters of J. Francis Fisher, Esq., of Philadelphia). Mr. Morse cast some type in 1833, but from limited circumstances was compelled to desist from farther experiment, until his appointment to a professorship in the University of New York, in 1835, when he formed the annexed mechanical arrangement, which is interesting from the fact, that it is the basis on which a long series of improvements have been made to bring the instrument to its present unique construction. He exhibited it in January, 1836, to Mr. L. D. Gale, a colleague professor in the University of high scientific attainment, who afterwards joined Mr. Morse in his enterprise, and made some useful suggestions for its improvement. But becoming satisfied that the electro-magnetic power was more available for telegraphic purposes, as exemplified by the experiments of Prof.

attention, but this is thrown aside, as the click of the register answers the purpose; some experienced operators become so accustomed to this click that they can declare the message without referring to the character made by the style; thus it becomes phonetic, and operators conversing at vast distances, can make the little instrument, by its varied action, slow, rapid, or impetuous, give expression to the different feelings of the mind; each office has its own peculiar signal, known to all the rest on the line, and an answer is expected as soon as it is given.

The machine is wound up by a key fixed to the axis of the largest wheel on the left; some guides are used to conduct the paper beneath the style with such regularity that several communications may be printed parallel to each other on the same strip.

An improvement in the Morse Telegraph Register, made by James J. Clark, of this city, consists of the register keeping itself constantly wound up, so that the operator is not troubled in using the winding key. It also secures a uniformity of motion throughout any number of messages. The winding motion is obtained by an extra magnet being placed in the register, and the closing and breaking of the circuit causes a lever to vibrate. This lever has a click at its end, acting in a small steel ratchet-wheel, which causes the ratchet-wheel to revolve and transmit its motion by wheel gearing to the shaft of a spring contained in a box, like a watch. A spring is used for a motive power to the train of wheels, instead of a weight, as in the ordinary register. There is also an arrangement by which it ceases winding when the spring is wound to the power necessary to revolve the train of wheels. This is effected by two points coming in contact and establishing a cross-current, which cuts off the current from the winding magnet, until, by its running, it causes the two points to separate, when the current flows through the magnet again, and the winding is continued. The instrument is beautifully finished, and reflects credit on the maker.

The peculiar form of magnet used in the registering department, is seen in the diagram No. 2, to the right of the register. A A, the circuit connections; C C, lower extremities of the soft iron bars, which are joined together; H H, reels of the helices around the iron; F F, the upper ends of the soft iron, having opposite polarities; P, the point of connection between the wires of the two helices; E, the armature. [B, above, represents the operating key of a distant office, situated on the main line, with the attendant in the act of transmitting a communication; O, the main line coming from the distance; A, the battery on that line. Groves's battery is mostly in use, 30 cups of which are necessary in a space of 150 miles; they may be kept in one body, but it is better to distribute them at intervals along the line; they require cleansing and replenishing about once a fortnight. After passing through the key, the main circuit follows the course of the arrow to the receiving magnet C on the right, traverses the helix of that, and issues again from it, continuing its course to the right, to the next station, and so it might go on indefinitely, or around the world; N is

the local operating key through which the line passes in the same manner as at B; this is the entire relation of the main circuit to an office; it makes the receiving magnet close the local circuit, and it will do it not only at one station, but at all on the same line, and at the same time; so that an operator in Philadelphia can transmit his message to St. Louis, and drop it at all the intermediate stations at one and the same moment; this has actually been performed.

Only one wire is now used on the main line, the earth affording the return circuit; No. 3 shows it very well; one end of the line may be supposed at Philadelphia, the other at New York; M M, receiving magnets of the two stations; K K, the operating keys respectively; P and N, the positive and negative poles of a battery on the line; C C, plates where the wires terminate in the ground: the connection of the wires to a gas-pipe will answer every purpose; the arrows represent the direction of the current; G, that portion of the ground forming the circuit. By having two wires, one connected respectively to the keys and magnets of the different offices, communications may be sent both ways at the same time, but only one current can traverse the same line at once.

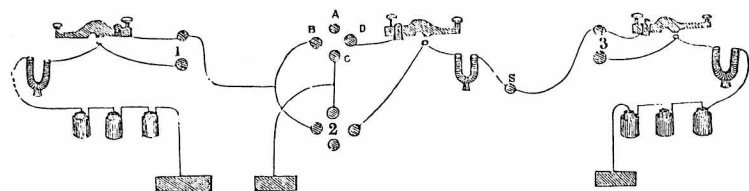
The local circuit Z is short, simple, and effective, being closed by the receiving magnet C; the current starts from the local battery R, consisting usually of from two to three cups, that must be cleansed every morning for efficient operation, runs through the helix D, back to the receiving magnet in the course of the arrow to the local battery; this causes the style to raise and make an impression on the paper; the whole operation then is very simple; the key depressed at a distant city or station, B, causes the receiving magnet C, at Philadelphia, to close the local circuit: the iron of the helix D is made instantly magnetic, and the style goes against the paper, and stays there as long as the key is kept down at B. A simple contact makes a dot (.), a longer time a line (—). Considerable experience is requisite to make a good operator, either to transmit or read messages; some, however, become quite proficient after three months' tuition; the interval between the times of contact is regarded as well as the letter, for by its length, letters, words and sentences, are distinguished from each other; the adjoined table contains the Morse telegraphic characters.

A —	J — — —	S — —	Numerals. 9 — — —
B — — —	K — — —	T —	1 — — — 0 — — —
C — —	L — —	U — —	2 — — —
D — —	M — —	V — — —	3 — — —
E —	N — —	W — — —	4 — — —
F — —	O — —	X — — —	5 — — —
G — — —	P — — —	Y — — —	6 — — —
H — — —	Q — — —	Z — — —	7 — — —
I — —	R — —	& — — —	8 — — —

If an operator at Philadelphia wishes to send a communication to Baltimore, he first breaks the main circuit by opening the operating key at his station. All the receiving magnets in that circuit cease to attract their armatures, the spring draws them away from the magnets, and thus breaks all the short office circuits. The Philadelphia ope-

screw at S, the left or right-hand wire may thus be brought in connection with the ground. The buttons 1, 2, and 3, are simply used as convenient duplicate keys, or circuit closers, when the operator is receiving."

Fig. 32.



When the line is found deranged at an intermediate office, by the evidence of a current unnaturally strong or weak, the impression is that the wire is broken at one or both sides of the office. Supposing the wire continuous from one end of the line to the other, and a battery at each, the current passes through the intermediate magnet without interruption, and the circuit established is termed a "through circuit." When a derangement is perceived, the intermediate operator alters the through circuit, and by connecting with the ground, makes two short circuits.

Several methods have been devised to obviate the disastrous consequences that sometimes result from violent electrical action during thunderstorms, such as the melting or breaking of wires, total destruction of long distances of the circuit, injury to office furniture or the operators connected with it; among the most important of which are those that combine the readiest communication with the ground to convey away the superabundant fluid; one is to have the circuit closer of a receiving magnet, employed for this sole purpose, pass into the earth; another is the metallic connection with the surface of a brass ball, surrounded by a ring situated in and forming part of the circuit, from the inner circumference of which minute metallic points project towards, but do not quite touch the ball; both of these, however, are inefficient at times.

Professor Morse has deservedly received the highest approbations of the American people for the invention that not only calls forth wonder at its accomplishments, but has proved itself an invaluable agent in political economy. Excepting efficient and economical batteries, most of the discoveries in this department of science had been made, which were essential to a proper foundation of his invention; some hand was necessary to elicit the remaining facts, combine and give them a mechanical arrangement and application, and then to thrust it before a distrustful public, to solicit the attention and patronage of the government for the proper attestation of its merits.

It was novel to the American people; no one had projected the thing here successfully, though many had thought of, and some tried it; through Professor Morse's indefatigable perseverance, the adjutant

resources of science were united in the form of utility; though dependent for most of his information upon others, he had the confidence in its final success, to master opposing obstacles, and bring to his aid those who had labored honorably and prosperously in the progress of knowledge.

Professor Morse has received numerous testimonials of the high appreciation in which his form of telegraph is held in Europe, one of the most recent of which was "the State medal" from the King of Wurtemberg, with the information that his form of telegraph will be adopted in that kingdom. The Grand Sultan of Turkey, also, did Professor Morse the same honor, followed by the King of Prussia, with the adoption of his form of telegraph for great distances.

And their scientific men have not withheld their high estimation of its simplicity and utility. Professor Steinheil, the Administrator-in-chief of the Austrian telegraphs, although himself the inventor of an electric telegraph, which has procured for him a world-wide and well-deserved fame, with a magnanimity which does him high honor, has given his opinion in favor of adopting the American system in Germany.

The following is a translation of the official act:—

"Extract from the Protocol of the Convention of Deputies from the German Governments which met at Vienna in the month of October, 1851, for the establishment of a German Austrian Telegraphic Union, &c.:—

"The Governments of this Union give their mutual assurance to bring into operation, at the latest, on the 1st of July, 1852, the direct transmission of telegraphic communications between the central stations of the respective governments, so that transfers upon intermediate stations will be no longer required, whenever the lines are not previously occupied, so that each of the central stations can enter into communication with every other.

"To accomplish this, all the Governments of the Telegraph Union adopt for the International Correspondence upon each line, for the present, Morse's Telegraph, with receiving magnets, registers, and uniform alphabet."

Morse Telegraph Convention.

A Telegraph Convention assembled at Washington on the 5th day of March, 1853, to confer together for the purpose of establishing regulations among the various Morse Telegraph Companies, so as to increase the farther usefulness of this means of transmission, and to perfect the system to its greatest capacity of good.

The Committee on Resolutions reported on the following points, which were adopted in detail by the Convention:—

First. All words in the body of a message should be counted. Proper names, such as the names of persons, steamers, cities, &c., shall be counted as many words as there are capitals used.

Second. Better means recommended to secure answers to messages

sent, and to give priority to messages of inquiry between offices on business.

Third. A reciprocal rule for refunding on lost messages, making the line at fault responsible.

Fourth. To protect the telegraph from abuse by unworthy and unqualified operators, requiring suitable evidence of integrity and capability.

Fifth. A uniform system of numbers and signal letters.

Sixth. The recommendation to decline adopting new letters in the Morse alphabet, but agreed to the transposition of the letters "C" and "K," requiring the dash, dot and dash to be used as "C," and the spaced letter "C" to be used in future as "K."

Seventh. Refusal to adopt any periodical for an official organ of the Convention or Telegraph.

Eighth. Refusal to adopt the general term of National Telegraph, considering it as a name applied to associated lines.

Ninth. The extension of the patent of 1840 was considered the legitimate business of the patentee.

Tenth. Declined to reduce the tariff of charges by an increase of words.

Eleventh. The appointment of a Committee of Correspondence, to serve until the next Convention, to attend to such matters relative to the general interest of Telegraph Companies as may be deemed necessary.

Twelfth. No message to be transmitted by any line unless prepaid, except answers to messages, checked "answer paid."

Thirteenth. Recommending the abolition of the practice of sending free messages, except for those actually engaged in the business, and on telegraph business.

Fourteenth. Against the employment of persons without good testimonials of integrity, &c.

Fifteenth. The Convention agreed to meet annually, and in Washington, March, 1854.

Sixteenth. Recommending offices in same cities to unite, and have one office, common to all.

Much important business was transacted with great unanimity.

The Convention in a body called and paid their respects to the President of the United States, at the Executive mansion, and were courteously received by him. The members composing the Convention represented about four-fifths of the Telegraph lines of America.

The Convention adjourned *sine die* at 7 o'clock P. M.

Wheatstone and Cooke's Needle Telegraph.

In 1834, Professor Wheatstone published a beautiful series of experiments on the velocity of electricity, which I noticed in the first of these lectures on the Telegraph. This seems to have had an influence in directing his attention to the subject of the Electric Telegraph. During the month of June, 1836, in a course of lectures delivered at King's College, London, he repeated his experiments on the velocity of electricity, but with an insulated circuit of copper wire, the length

of which was now increased to nearly four miles; the thickness of the wire was $\frac{1}{16}$ of an inch.

When machine electricity was employed, an electrometer placed on any point of the circuit diverged, and wherever the continuity of the circuit was broken, very bright sparks were visible. With a voltaic battery, or with a magneto-electric machine, water was decomposed, and the needle of a galvanometer deflected in the middle of the circuit. Prof. Wheatstone gave a sketch of the means by which he proposed converting his apparatus into an electrical telegraph, so that, by the aid of a few finger stops, it would instantaneously and distinctly convey communications between the most distant points. The apparatus, as it is at present constructed, is capable of conveying thirty simple signals, which, combined in various manners, will be fully sufficient for the purposes of telegraphic communication.—*Mag. Pop. Sci.* 1836.

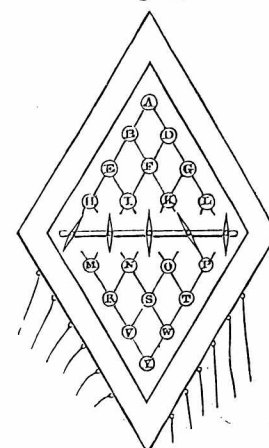
This was Prof. Wheatstone's first telegraph, and, having matured his plans, he took out a patent on the 12th of December, 1837, which was sealed on the previous 12th of June, 1837, in conjunction with Mr. W. F. Cooke, who had devoted much of his time and attention to the practical application of the Electric Telegraph.

The principle on which this telegraph depended, was that of combining several peculiarly constructed galvanometer needles. It was an application of the famous discovery of Prof. Ørsted of the deflecting influence of an electric current upon a magnetic needle, which I have already explained in a previous lecture.

A signal board was employed, having five vertical galvanometers with double needles, the lower ends of each being slightly the heaviest, so as to insure at all times a vertical position, except when deflected by the current. From the ends of these needles lines were drawn, both above and below, as in Fig. 33, and at the points where these lines intersected, letters and numbers were placed. When an electric current was transmitted so as to deflect at the same time two of the needles, they indicated, by their convergence, one or other of the letters marked on the signal board. Thus, if the first and fifth needles converged above, they pointed to A; if below, to Y; or if the first and fourth converged above, they indicated B, and so on.

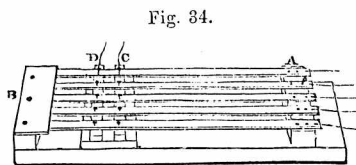
The signal boards were placed at either end of the line of telegraph, having a battery and keys so arranged as to render it easy to deflect at pleasure any of the five galvanometer needles at the distant station; the two sets of galvanometers being connected by six wires, one for each separate needle, and one as a return common to them all. The keys used to

Fig. 33.



connect these wires with the battery were very simple, and at the same time perfectly efficient.

The arrangement consisted of five copper bars, thin enough to be elastic, fastened to a crosspiece of wood, as at A, Fig. 34, and connected with the five wires of the telegraph, whilst their other ends pressed slightly (but so as to be in good metallic contact) against a crosspiece of copper, B. The terminal wires of the voltaic battery were attached to two small



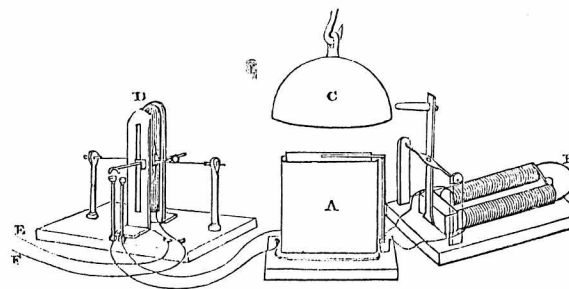
bars of metal, C D, and in the five longer bars, just where they crossed the battery bars C D, there was a row of small metal pins, terminated with little ivory knobs. When it was desired to deflect any of the needles in the signal boards, all that was necessary was to press the ivory knobs above those bars, in connection with the needles to be deflected; the slight pressure, by bending down the bars, insulated them for the time by breaking the contact at B; and the metal pins, by coming in contact with the crossbars C and D, became connected at once with the battery. By this simple arrangement the keys, though always ready for immediate use in sending a signal, were not any obstacle to receiving one, as the bar B always completed the circuit of all the wires, except at the moment of using the telegraph, and then, by the contrivance just described, it was thrown out of connection. The wires of this first telegraph were insulated in tubes by means of a mixture of cotton and India rubber; then the prepared wires are all passed with certain precaution through iron pipes, which on some parts of the line were buried beneath the ground, and in others raised above it. It was afterwards elevated on wooden posts, as the moisture affected the wires, and destroyed the insulation. The battery employed by them was that of a vessel of copper, with plates of zinc, and acidulated water.

In order that the telegraph could be practically used, it was essential that some simple means should be employed to call the attention of the operator when a message was about to be sent, as the movement of the needles made no sound.

In order to overcome the difficulty presented by the very small amount of power which would be transmitted to a long distance, and which was not sufficient to make an electro-magnet of any power, and thus discharge an alarm, he placed a second battery at the distant station, having wires connected with a powerful electro-magnet attached to an alarm, or arranged so as to strike a bell as soon as the battery was brought into operation. But, as the circuit was broken, the battery, though charged with acid, and therefore ready to act, could not exert its magnetizing power on the electro-magnet unless the circuit was completed. The current of electricity from the distant station from whence the intelligence was to be transmitted, though not powerful enough to make an electro-magnet, was abundantly powerful

enough to complete the circuit of the second battery, thus waiting to be called into action. This was effected by a small piece of copper wire attached to a crosspiece fastened to a delicately suspended vertical galvanometer; when the latter was deflected by even a feeble electric current, the copper wire, by having its ends plunged into two cups of mercury, completed the circuit of the secondary battery, causing the electro-magnet to attract its keeper, and thus let off the alarm to ring the bell. The general form of the arrangement is represented in Fig. 35, which I have taken from a published lecture by Professor E. Solly, of London, on the telegraph, which drawing proves correct on comparing it with the original in the patent.

Fig. 35.



E F are the wires conveying the electric current from the distant station; D, the vertical galvanometer deflected by its influence; A, the secondary battery thus brought into action, and B, the electro-magnet which is made to act on the bell C.

The line of telegraph upon the Great Western Railway was finished in July, 1839, and had been in operation above seven or eight months. Thirty signals may be conveniently made in a minute. According to Professor Wheatstone, on his examination before a Parliamentary Committee on Railways in 1840, he states: "I have been confining the attention of the Committee to the telegraph now working on the Great Western Railway, but having lately occupied myself in carrying into effect numerous improvements which have suggested themselves to me, I have, conjointly with Wm. Cooke, who has turned his attention greatly to the same subject, obtained a new patent for a telegraphic arrangement, which I think will present very great advantages over that which at present exists. This new apparatus requires only a single pair of wires to effect all which the present one does with five, so that three independent telegraphs may be immediately placed on the line of the Great Western; it presents in the same place all the letters of the alphabet according to any order of succession, and the apparatus is so extremely simple, that any person without any previous acquaintance with it can send a communication and read the answer."

Mr. Saunders, the secretary of the Great Western Railway, states

THE
TELEGRAPH MANUAL:

A COMPLETE
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Semaphoric, Electric and Magnetic Telegraphs
OF

EUROPE, ASIA, AFRICA, AND AMERICA,
ANCIENT AND MODERN.

WITH SIX HUNDRED AND TWENTY-FIVE ILLUSTRATIONS.

Et non "eripuit celo fulmen,"
Fulguri mentem fudit, et orbem lumine cinxit.—PITLÉ.

BY TAL. P. SHAFFNER,
OF KENTUCKY.

T. P. Shaffner

NEW YORK:
D. VAN NOSTRAND No. 192 BROADWAY.
1867.

There may be a mistake in the supposition, that the telegraph of Baron Schilling had been exhibited to Alexander, as that Emperor died in 1825, and there is no evidence to show that the telegraph had been devised by Baron Schilling thus early.

From the report of the "Academy of Industry," Paris, February, 1839, I make the following extract, in relation to the same subject:

"At the end of the year 1832, and in the beginning of 1833, M. Le Baron de Schilling constructed, at St. Petersburg, an electric telegraph, which consisted in a certain number of platinum wires, insulated and united in a cord of silk, which put in action, by the aid of a species of key, thirty-six magnetic needles, each of which was placed vertically in the centre of a multiplier. M. de Schilling was the first who adapted to this kind of apparatus, an ingenious mechanism, suitable for sounding an alarm, which, when the needle turned at the beginning of the correspondence, was set in play by the fall of a little ball of lead, which the magnetic needle caused to fall. This telegraph of M. de Schilling was received with approbation by the Emperor, who desired it established on a larger scale, but the death of the inventor postponed the enterprise indefinitely."

Dr. Steinheil, in his article "upon telegraphic communication," published in the London Annals of Electricity, states, that "the experiments instituted by Schilling, by the deflection of a single needle, seems much better contrived than the arrangement Davy has proposed, in which illuminated letters are shown by the removal of screens placed in front of them."

It would appear that the French report is either incorrect, or that M. de Schilling had two plans in contemplation. His plan as intimated in the first and third extracts, is that of using a single needle in the form of a galvanometer, by means of which he made his signals; for instance, one deflection to the right might denote *e*, two *i*, three *b*; one deflection to the left *t*, two *s*, three *v*. His code of signals would then be devised in the manner shown on the following page.

If, however, his plan was that ascribed to him, by the Academy of Industry, of using thirty-six needles and seventy-two wires, it was exceedingly complicated and expensive, and was similar to that invented by Mr. Alexander, with the exception that Schilling used twice the number of wires.

During my recent residence in St Petersburg, I endeavored to obtain some further information in regard to this telegraph, but it was not possible to discover more than is embraced above

BARON SCHILLING'S CODE OF SIGNALS.

rl	A	rrrl	K	llr	U
rrr	B	lrrr	L	lll	V
rlI	C	lrl	M	rlrl	W
rrl	D	lr	N	lrll	X
r	E	rlr	O	rlrr	Y
rrrr	F	llrr	P	rlrr	Z
llll	G	lllr	Q	rrlr	&
llll	H	lrr	R	llrl	go on
rr	I	ll	S	llrl	stop
rrll	J	l	T	llrl	finish

rlrlr	1	llrlr	6
rrlrr	2	rrllr	7
rlllr	3	rlrrr	8
lrrrl	4	llrll	9
lrrll	5	llrrl	0

GAUSS AND WEBER'S ELECTRIC TELEGRAPH.

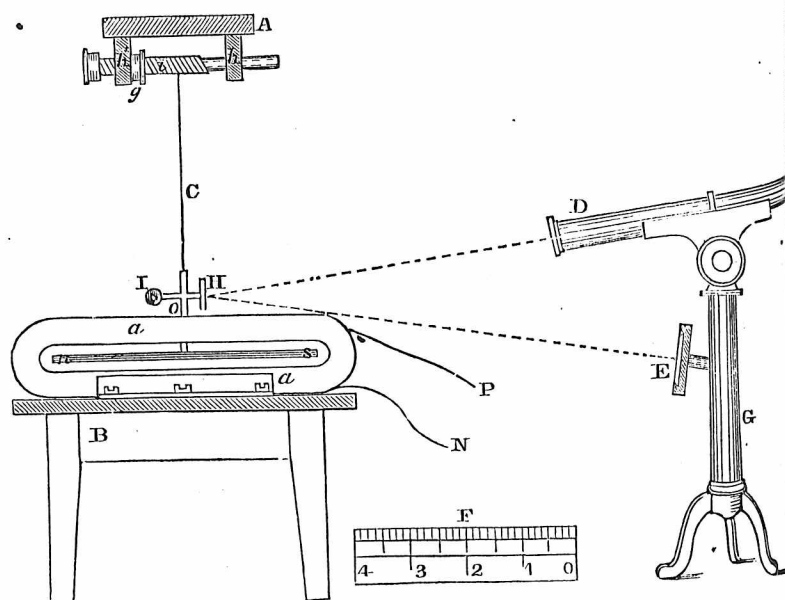
This telegraph seems, by the best authorities, to have been invented in 1833, by Counsellor Gauss and Professor Weber, at Gottingen.

The deflection of the magnetic bar, by means of the multiplier, through the agency of the galvanic fluid, excited by the magneto-electric machine, is the basis of their plan.

Fig. 2 represents a side view of the apparatus, used at the receiving station; *a a* is a side view of the multiplier, composed of 30,000 feet of wire (almost five and a half miles), upon a table *B*; *ns* is the magnetic bar, weighing thirty pounds, from which rises a vertical stem, *o*, upon which is a rod at right angles, supporting a mirror *H*, on one end, and at the other a metallic ball *i*, as a counteracting weight to that of the mirror. The magnetic bar is suspended by a small wire, fastened to the vertical stem, and at the top is wound round the spiral of the screw *i*, which turns in the standard *h'* and *h*, upon the platform *A*, and which is secured to the ceiling. In the standards *h'*, there is cut a female screw, of the same gradation as that upon which the wire is wound. By this means, the magnetic bar may be raised or let down, by turning the screw, without taking the bar from its central position in the multiplier; *g* is a screw for fastening the spiral shaft, when properly adjusted. *r* and *n* are the two ends of the wire of the multiplier. *e* is a stand for supporting the spy-glass *v*, and also the case *E*, into which slides the scale *f*. The mirror *H* is at right angles with

the magnetic bar, and presents its face to the spy-glass D, as also to the scale at E. It is so adjusted, that the reflection of the scale at E from the mirror, may be distinctly seen from the spy-glass. If the magnetic bar turns either to the right or left, the mirror must move with it, and if a person is observing it through the spy-glass, the scale will appear to move at the same time, thereby presenting to the eye of the observer another part of the scale than that seen when the bar is not deflected. The figures on the scale will show in what direction the bar has

Fig. 2.



turned, and thus render it distinct to the observer, the only apparent object of the mirror, spy-glass, and scale.

For the purpose of generating the galvanic fluid, they use the magneto-electric machine. There is also required for the purpose of making the desired deflections of the magnetic bar, a communicator or pole-changer. Fig. 2 represents that portion of the apparatus at the *receiving* station. The magneto-electric machine, and the pole-changer, properly connected, are the instruments of the *transmitting* station. Two wires, or one wire and the ground, form the circuit between these two stations. The machine is put in operation by turning the crank, and the person sending the intelligence is stationed at the com-

mutator, and directs the current through the extended wires to the multiplier of the receiving station, so as to deflect the bar to the right or left, in any succession he may choose, or suspend its action for any length of time.

But in the apparatus for observation, the observer looks into the spy-glass, and writes up the kind and results of the variations of the magnetic needle. In order to have a control of the recorder, let there be a good number of spy-glasses directed toward the same mirror, in which observers may watch independently of each other. Suppose that five variations of the magnetic needle signifies a letter, *l* denotes a variation to the left, and *r* to the right. Then might *rrrrr* denote A, *rrrl* denote B, *rrllr* C, *rrlll* D, and so on. In the whole, we obtain by the different arrangements of the five, which are made with the two letters *r* and *l*, thirty-two different telegraphic signs, which may answer for letters and numbers, and of which we can select those where the most changes are introduced between *r* and *l*, as the most common letters, in order, in the best possible manner, to notice the constant variations of the magnetic needle.

The following would be the alphabetical and numerical signs, as arranged from the above directions:

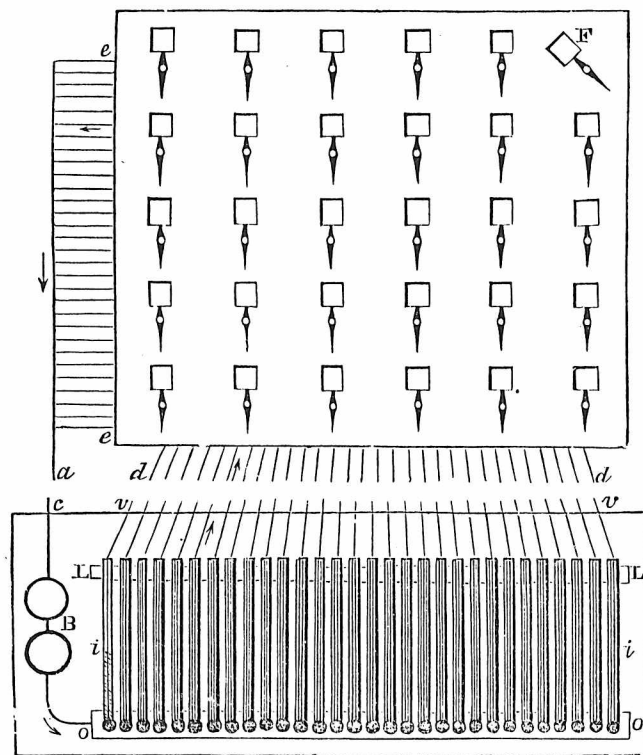
A	rrrrr	I or Y	llrl	R	rrrl
B	rrrrl	K	lrrrl	S or Z	rrlrl
C	rrrlr	L	rlrrr	T	llrlr
D	rrllr	M	rrlll	U	rlllr
E	rlrlr	N	lllll	V	lrrll
F	lrrrr	O	lrlll	W	llllr
G or J	lrlrr	P	lrlrl		
H	rlrrl	Q	llrrr		

1	rllll	:	6	rlrrr
2	rrllr	:	7	lllrl
3	rlrlr	:	8	llrrl
4	rllrl	:	9	lrrlr
5	lllrr	:	0	lrlrr

A model to illustrate the nature and powers of this machine was exhibited at the Society of Arts in Edinburgh, Scotland, November, 1837. The model consists of a wooden chest, about five feet long, three feet wide, three feet deep at the one end, and one foot at the other. The width and depth in this model

are those which would probably be found suitable in a working machine; but it will be understood that the length in the machine may be a hundred or a thousand miles, and is limited to five feet in the model, merely for convenience. Thirty copper wires extend from end to end of the chest, and are kept apart from each other. At one end (which, for distinction's sake, we shall call the south end) they are fastened to a horizontal line of wooden keys, precisely similar to those of a pianoforte; at the other, or north end, they terminate close to thirty small apertures, equally distributed in six rows of five each, over a screen of three feet square, which forms the end of the chest. Under these apertures on the outside, are painted, in black paint, upon a white ground, the twenty-six letters of the alphabet, with the necessary points, the colon, semicolon, and full point, and an asterisk, to denote the termination of a word. The letters occupy spaces about an inch square. The wooden keys, at the other end, have also the letters of the alphabet,

Fig. 3.



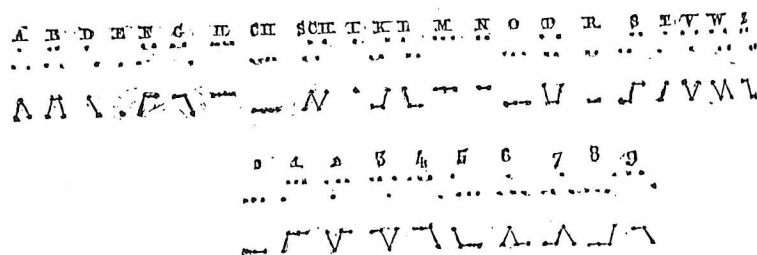
painted on them in the usual order. The wires serve merely for communication, and we shall now describe the apparatus by which they work.

This consists, at the south end, of a pair of plates, zinc and copper, forming a galvanic trough, placed under the keys; and at the north end, of thirty steel magnets, about four inches long, placed close behind the letters painted on the screen. The magnets move horizontally on axes, and are poised within a flat ring of copper wire, formed of the ends of the communicating wires. On their north ends they carry small square bits of black paper, which project in front of the screen, and serve as opercula, or covers, to conceal the letters. When any wire is put in communication with the trough at the south end, the galvanic influence is instantly transmitted to the north end; and in accordance with the well-known law, discovered by Ørsted, the magnet at the end of that wire instantly turns round to the right or left, bearing with it the operculum of black paper, and unveiling a letter. When the key, A, for instance, is pressed down with the finger at the south end, the wire attached to it is immediately put in communication with the trough; and at the same instant, letter A, at the north end is unveiled, by the magnet turning to the right, and withdrawing the operculum. When the finger is removed from the key, it springs back to its place; the communication with the trough ceases; the magnet resumes its position, and the letter is again covered. Thus by pressing down with the finger, in succession, the keys corresponding to any word or name, we have the letters forming that word, or name, exhibited at the other end; the name VICTORIA, for instance, which was the maiden effort of the telegraph, on the exhibition before the Society of Arts, above referred to.

The above description is all that I have been able to obtain in relation to this plan of an electric telegraph; and here introduce, fig. 3, to illustrate it. The thirty needles are represented on the screen, each carrying a shade, which conceals the letter when the needle is vertical. The needle belonging to the letter F, is, however, deflected, and the letter is exposed. The screen is supposed to be at the receiving station. To the left hand of the screen, thirty wires, e e, are seen joined to one, a; the other thirty wires, d d, are seen below the screen.

erals arranged as the following, which must be regarded as their true and proper organization.

Fig. 24.



THE DISCOVERY AND INVENTIONS OF STEINHEIL.

From the foregoing, in regard to the discovery and inventions of Prof. Steinheil, it will be observed that he produced the following facts, viz.:

1st. That he invented a tangible and practical writing electric telegraph, demonstrated by the most complete experiments;

2d. That he invented an electric telegraph, which actually communicated intelligence by sound, methodically arranged, suitable for commercial purposes;

3d. That he discovered the earth circuit, as practically applied in the electric telegraphic art, with all systems throughout the world

4th. That he first organized the system of poles and insulators, for the suspension of metallic conductors in the air for electric telegraphing;

5th. And that he established the fact, by actual experiment, that a current of electricity, generated by a magnetic organization, can be practically applied for telegraphing.

HISTORY OF THE ENGLISH ELECTRIC TELEGRAPH

CHAPTER XIII.

William Fothergill Cooke and the Telegraph—Möncke's Electrometer Experiments—The English Electric Telegraph invented—Invention of the Alarum—The Mechanical Telegraph—The Escapement Apparatus—Mr. Cooke's Efforts to put his Telegraph in Operation—The Second Mechanical Telegraph—Wheatstone's Permutating Key-Board—Messrs. Cooke and Wheatstone become associated—The Secondary Circuit invented—Mr. Cooke improves his Original Telegraph—All the Improvements combined—Description of the Apparatuses—Improvements patented in 1838—Wheatstone's Mechanical Telegraph—Further Improvements by Mr. Cooke.

WILLIAM FOTHERGILL COOKE AND THE TELEGRAPH.

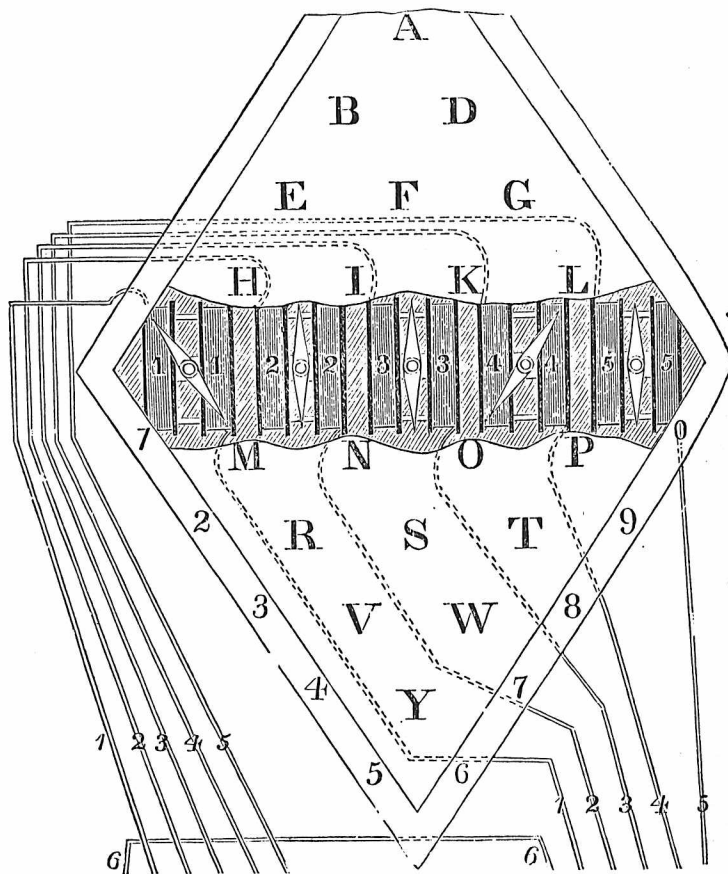
THE English Electric Telegraph, invented by William Fothergill Cooke, will be the subject of consideration in the present chapter.

It is not my purpose to discuss the questionable claims of others, in regard to their participation as auxiliaries in the perfection of the above-mentioned telegraph. It is my purpose to give the facts with but little comment. The reader can exercise his own judgment in the premises.

In the month of March, 1836, Mr. Cooke was engaged at Heidelberg in the study of anatomy, in connection with the interesting, and by no means unprofitable profession of anatomical modelling; a self-taught pursuit, to which he had been devoting himself with incessant and unabated ardor. On the 6th of March, 1836, he witnessed an electro-telegraphic experiment, exhibited by Professor Möncke of Heidelberg, who had, perhaps, taken his idea from Gauss. Mr. Cooke was so much struck with the wonderful power of electricity, and so strongly was he impressed with its applicability to the practical transmission of telegraphic intelligence, that, on that very day, he entirely abandoned his former pursuits, and devoted himself

five electrometers and their wires (shown at the opening in the dial board), and numbered, 1, 1; 2, 2; 3, 3; 4, 4, and 5, 5. The coils of the multipliers are secured with their needles to the case, having each exterior needle projecting beyond the dial, so as to be exposed to view. Of the wires from the coils, five are represented as passing out of the side of the case, on the left hand, and are numbered 1, 2, 3, 4, and 5. The other five wires pass out on the right hand, and are numbered in the same manner. The wires of the same number as the electrometer, are those which belong to it, and are continuous. Thus the wire 1, on the left hand, proceeds to the first coil of electrometer 1, then to the second coil, and then coming off,

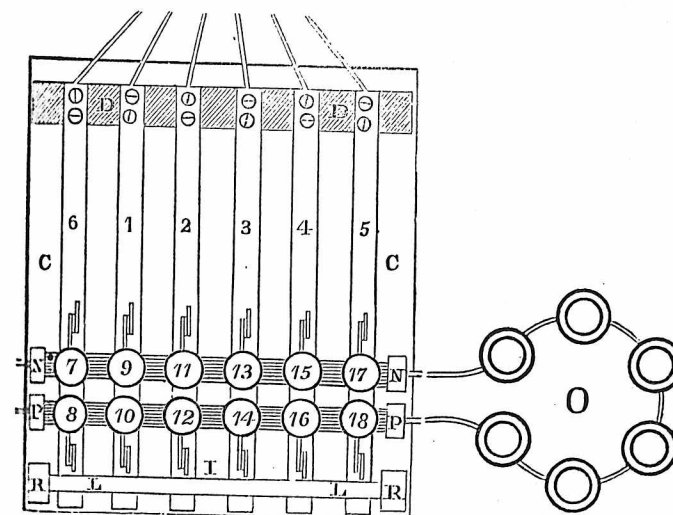
Fig. 23.



passes out of the case, and is numbered 1, on the right hand. So of the other wires, thus numbered. The dial has permanently marked upon it at proper distances and angles, twenty of the letters of the alphabet, viz. A, B, D, E, F, G, H, I, K, L, M, N, O, P, R, S, T, V, W, Y. On the margin of the lower half of the dial are marked the numerals, 1, 2, 3, 4, 5, 6, 7, 8, 9 and 0. The letters, C, J, Q, U, X, Z, are not represented on the dial, unless some six of those already there are made to sustain two characters each, of which the specification is silent. Each needle has two motions; one to the right, and the other to the left. For the designation of any of the *letters*, the deflection of two needles are required, but for the *numerals*, one needle only. The letter intended to be noted by the observer, is designated, in the operation of the telegraph, by the *joint deflection* of two needles, pointing by their convergence to the letter. For example, the needles, 1 and 4, cut each other, by the lines of their joint deflection, at the letter v, on the dial, which is the letter intended to be observed at the receiving station. In the same manner any other letter upon the dial may be selected for observation. Suppose the first needle to be vertical, as the needles 2, 3, and 5, then needle 4 being only deflected, points to the numeral 4, as the number designed.

I will now proceed to describe the arrangement of the springs and buttons upon the platform, c c, figure 24 (representing a

Fig. 24.



with their respective, electrometers, and thence they are continued and soldered to their springs of the key arrangement, with the exception of wire number 6, which passes direct to the key 6, without going through the dial case. In both figures, is represented the battery, *o*, consisting of six cups. The wire from one pole of the battery is connected with the *n* metallic plate, the other wire with the *r* metallic plate. While none of the buttons are pressed down, the battery is *not* in action, and it will also be observed, that the circuits are all *complete*. The action of the keys, then, is this, by a single operation to break the circuit formed with the cross-bar, *L*, and, at the same time, bring *into* the circuit, the battery, *o*.

The following numbers, representing the buttons, are those necessary to be pressed down, in order to signal the letters and numerals on the dial :

Letters.

For A, buttons 10 and 17.	For M, buttons 9 and 12.
" B, " 10 " 15.	" N, " 11 " 14.
" D, " 12 " 17.	" O, " 13 " 16.
" E, " 10 " 13.	" P, " 15 " 18.
" F, " 12 " 15.	" R, " 9 " 14.
" G, " 14 " 17.	" S, " 11 " 16.
" H, " 10 " 11.	" T, " 13 " 18.
" I, " 12 " 13.	" V, " 9 " 16.
" K, " 14 " 15.	" W, " 11 " 18.
" L, " 16 " 17.	" Y, " 9 " 18.

Numerals.

For 1, buttons 7 and 10.	For 6, buttons 8 and 9.
" 2, " 7 " 12.	" 7, " 8 " 11.
" 3, " 7 " 14.	" 8, " 8 " 13.
" 4, " 7 " 16.	" 9, " 8 " 15.
" 5, " 7 " 18.	" 0, " 8 " 17.

The direction of the current, when the letter *v* is to be signalled, is this: pressing down the buttons, 9 and 16, at the Paddington station, the fluid leaves the battery, *o*, along the wire to the cross bar, *r*; then to the hammer of the button, 16; then to the spring, 4; then along wire 4, to the electrometer, 4, and through it, deflecting the lower half of the needle to the left; then along the extended wire, 4, to the dial, and electrometer, 4, of the Slough station, deflecting the lower half of that needle to the left; then to wire, 4, leaving the dial, to key, 4; then to the cross-bar, *L* and *L*; and along the cross

bar to key, 1; then to wire, 1; then to electrometer, 1; and through it, deflecting the lower half of the needle to the right; thence it proceeds along the extended wire, 1, to the Paddington station; entering the dial to the electrometer, 1, deflecting the lower half of the needle to the right; then along wire, 1, to the key, 1; then to button 9; then to the cross-bar, *n*, beneath; and then to the negative pole of the battery, *o*. It will be observed, that the needles of both stations, thus deflected, point to the same letter *v*.

If a numeral is be signaled, it is obvious, that but one electrometer is needed. We will, therefore, suppose that the needle, 1, is vertical.

Let the buttons, 7 and 16, be pressed down, at the Paddington station. The current then leaves the positive pole of the battery, *o*, to the cross-bar, *r*; then to the key, 4; then along wire, 4, to electrometer, 4, deflecting the lower half of the needle to the left; thence to the Slough station to electrometer, 4, deflecting the lower half of the needle to the left; then to wire, 4; then to key, 4; then to the cross-bar, *L* and *L*, and along it to key, 6; then to wire, 6, and along the extended wire to the Paddington station, to key, 6; then to the cross-bar beneath the button, 7; then to the negative pole of the battery, *o*. The needles, 4 and 4, of both stations, are simultaneously deflected, so as to point to the figure, 4, on the margin of the dial.

In this manner the circuits required for each letter and numeral may be traced out. Now, suppose the message to be sent from the Paddington station to the Slough station, is this, "WE HAVE MET THE ENEMY AND THEY ARE OURS." The operator at Paddington presses down the buttons, 11 and 18, for signaling upon the dial of the Slough station, the letter *w*. The operator there, and who is supposed to be constantly on the watch, observes the two needles pointing at *w*. He writes it down, or calls it out aloud, to another, who records it, taking, according to a calculation given in a recent account, two seconds at least, for each signal. Then the buttons, 10 and 13, are pressed down, and the needles are observed to point at *e*; and so for the remaining letters of the sentence, *v* excepted, which has no letter on the dial.

The second English patent was sealed 18th of April, 1838, for an improvement, with the power of communicating from intermediate points in either direction; but when not working, the alarm belonging to it could be sounded from either termi-

Doc. G.

THE ELECTRIC TELEGRAPH COMPANY

LONDON STATION.

Date 185

Time
received,No. of
Words }

No.

From

Message	"
Portage	"
Paid out	"
Total	"

To

Signed

Clerk

AVY'S ELECTRO-CHEMICAL
TELEGRAPH.

CHAPTER XVI.

Nature of the Invention described—The Transmitting Apparatus—The Receiver
—The Instruments combined—The Manipulation—The Signal Alphabet.

NATURE OF THE INVENTION DESCRIBED.

On the 4th of July, 1838, was sealed a patent to Mr. Edward Davy, of England, for an electric telegraph, which combined the fundamental elements of subsequent chemical systems. The patent was very extensive, and embraced many valuable improvements in the art. It was bought by the Electric Telegraph Company of England, but never used.

The following outline description of the invention will serve to give an idea of its combinations:

Three wires were to be used, and points of metal wire were to be caused to press, by means of the motion of magnetic needles, upon chemically prepared fabric at the distant or receiving station.

The fabric to be employed was calico or paper, and it was to be moistened with a solution of hydriodate of potash and muriate of lime.

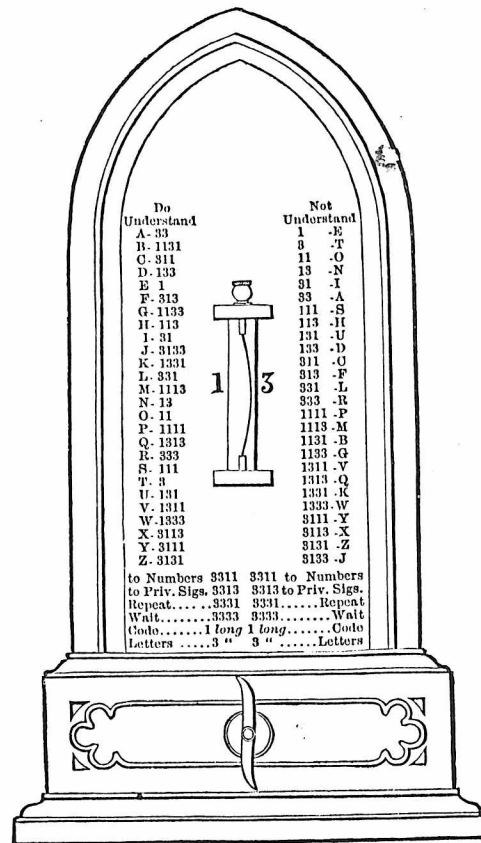
The motion of a needle to the right caused a mark to be made on *one* part of the fabric, and the motion of the same needle to the left, caused a mark to be made on *another* part of the fabric; and the same for *each* needle attached to the respective wires. Thus the single or combined marks were made to express letters or other desired symbols.

THE TRANSMITTING APPARATUS.

Fig. 1 represents a top view of the arrangement of the wires, mercury cups, and batteries of the *transmitting station*. The close parallel lines represent the wires, of which D A B and

mediate station, produces the requisite connections for causing an electric current to pass in either direction through the circuit, and, therefore, through the metallic leaf of the signal ap-

Fig. 2.



Gold-leaf Telegraph for one line-wire, with code-table shown on dial.

paratus of each terminal or intermediate station, and thus cause the metallic leaf of all the signal apparatuses to move simultaneously to either side, so as to give the required signal or signals.

"The key-board of each terminal or intermediate station has a handle, by moving which, the person in charge of the telegraph at any station can cause an electric current to pass through a circuit, in connection with a system of alarms at the terminal and intermediate stations, similar to those in use in magnetic-needle electric telegraphs."

The next patent was taken out in January, 1848, by Messrs. H. and E. Highton.

At this time Mr. Edward Highton was acting as telegraphic engineer to the London and Northwestern Railway Company, and was pressed by that company to invent a set of electric telegraphs free from the objections and defects inherent to most telegraphs then in use, and free also from any of the then existing patents.

Every telegraph proposed or executed at that time, was minutely investigated, and their defects studied with the greatest care. Neither time nor money was spared to accomplish the objects desired. The result was a series of inventions of great variety and extent.

For these inventions, the patentees received from the hands of His Royal Highness Prince Albert, as President of the Society of Arts, the greatest honor the society had the power to bestow, viz., their Large Gold Medal.

Several of the plans were immediately adopted on the London and Northwestern Railway, in preference to those of the old Electric Telegraph Company, who then possessed a great number of patents. The telegraphs gave the greatest satisfaction, and have been in constant daily use ever since.

The principal feature of the inventions in this patent were, viz.:

The horseshoe magnet was suited to coils, and was thought to be much superior to the old straight magnetic needle and coil of Cooke and Wheatstone. In step-by-step motion telegraphs, a means was provided for causing the pointer or disk at once to progress by one bound to zero on the starting point.

The maximum work capable of being produced by any number of lines was taken advantage of, and thus three wires were made to produce 26 *primary signals*, and so to show instantly any desired letter of the alphabet. Under Ampère's plan, 26 wires must have been used, and under Cooke and Wheatstone's patent, 6 wires. Suitable keys were devised for sending currents of electricity over three wires in the 26 orders of variation.

Direct-action printing telegraphs were devised, so that a single touch of one out of 26 keys caused instantly any desired one out of 26 letters or symbols to be printed.

The insulation of wires was improved, and many other improvements relating to electric telegraphs effected.

The advantage of the horseshoe magnet over the straight magnet or magnetic needle of Professor Wheatstone was thus stated by Mr. Highton: When a coil surrounds a straight magnetic needle, as used by Messrs. Cooke and Wheatstone, *each* convolution of the wire has to pass *twice* over the central or *dead part* of the magnet; whereas, if the horse-shoe magnet

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ELECTRICAL SCIENCE.

PUBLISHED UNDER THE SUPERVISION OF THE EDITING COMMITTEE,

AND EDITED BY

W. E. AYRTON, THE CHAIRMAN.

VOL. VII.—1878.

THE
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1878.

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The Seventieth Ordinary General Meeting of the Society was held November 27th, 1878, the President in the Chair.

After the transaction of the usual preliminary business, Major WEBBER, R.E., read a paper on

MULTIPLE AND OTHER TELEGRAPHS AT THE PARIS EXHIBITION.

Illustrated by ELISHA GRAY'S Harmonic Telegraph.

There have been epochs in the history of each branch of applied science, which, to those interested in their progress, mark fresh points of departure in the struggle for improvement. In the case of Telegraphic and Electrical Engineering, the various International Exhibitions have happened to coincide with certain stages of actual improvement and discovery, and there has been hardly one at which some fresh invention or application has not been almost for the first time made public; and this has been no less the case this year at Paris than in the past.

These coincidences are, of course, only accidental; but we have no less than others a duty to feel grateful to Exhibitions for the part they play in making public that which, but for them, might lie hidden for years.

Unfortunately, at Paris the various apparatus which, if brought together, would have formed a very interesting collection, were scattered up and down the building, and only in the French section was any display made convenient to the professional and general public.

As the only foreign juror for Class 65, I have, therefore, ventured to give to our Society a trifling notice of what could be found, believing that our Journal ought not to be left without any information as to one of the most important collections of telegraphic apparatus which has ever been brought together.

It may, also, be interesting to place on record the names, etc., of the Jury and its assistants, as all are members of this Society:—

JURORS.

Mons. Eduard Becquerel.
Mons. Bergon, of the French
Administration.
Major Webber, R.E.

JURORS SUPPLIANTS.

Le Capitaine Huc.
Mons. Baron.
C. E. Spagnoletti, Esq.

Expert to advise—Mons. le Comte du Moncel.

Acting-Secretary—Mons. Clerac.

It is of no small importance to the telegraph engineer, and to those who are interested in telegraphy, that, at all International Exhibitions since 1851, this application of electricity as an agent has been classed separately, and thus placed upon an equal footing in this respect with railway engineering; showing the estimation in which it is justly held, and the future which it is expected to attain.

In Class 65 at the Paris International Exhibition, so-called telegraphic apparatus have only been included, confining the class to the application of electricity as a means of communication, and only departing from the rule to make it embrace apparatus in which pneumatic means of motion are employed.

The consequences are, that the engineer or scientist who deals with all applications of the use of electricity as an agent, has to search in other Classes for the electric light, the electric pen, and other well-known apparatus.

Perhaps this system of classification may be deemed to suit best the popular understanding, but the real reason may appear plain, by the fact that the National Commissioners found that the easiest way to arrange the French section, and promote its chances of success, was to invite the French Telegraph Administration to take charge of its organisation, and bring together all the objects which are made in France for telegraphic purposes, and of which the Administration is naturally the largest customer.

While ensuring a very excellent exhibition of French telegraphic apparatus, this system of classification had the effect of marring the display for the other countries, which in this particu-

In fact, when both keys are depressed both armatures are closed, but the raising of A's key relieves B's armature, and *vice versa*.

When the stations are joined up to work with the same current, the key not being depressed, the sum of the currents at the two stations passes to earth, and the armatures are attracted.

When A's key is depressed, his current nearly all passes through the local, which relieves the armature at B, but that at A continues to be attracted because of the local current which enters α in the same sense as that from line, and maintains the strength of the relay at A.

It is probable that the plan of working with opposing currents would prove the best.

In each case the electro-magnets $y y'$ are arranged so as to compensate for discharge. At the moment of charging the line an induced current passes in the opposite sense through the secondary circuit of the relay α and the left hand bobbin of y (right of y'), neutralising the effect on the relays. The intensity of the induced current could be regulated by a rheostat placed in a shunt at R².

OLSEN.

The telegraph instrument of Mr. Olsen, of Christiania, deserves notice as an improvement on the model described by him in the *Journal de Berne* of 1876.

As readers of that paper are aware, the apparatus consists of two parts:—

1. The perforator;
2. A transmitting and receiving instrument;

The last is capable of use either as a manipulator or automatically, the greatest speed being of course obtained when used in the latter way.

In the perforator the improvements consist of a new arrangement of cams, which act on the perforating axle and its three punchers.

In the transmitting apparatus, the improvement consists in being able to send seven characters instead of five during one revolution of the type wheel. When recourse is had to automatic

transmission, the receiving portion can travel easily with a rate of 180 revolutions a minute.

The arrangements of the type and correcting wheel, as well as changing to figures, are precisely the same as in the Hughes.

For the means of correction, Mr. Olsen claims an improvement, as his arrangement gives a duration nearly double, viz., as 56 is to 30. On the other hand, he is obliged to employ two separate sets of clockwork, which only work as one during the revolutions of the printing shaft—one working only with the 'printing shaft, the second running constantly; however, the action of the same treadle moves both.

The work done by the perforators in the paper slip is identical with that in Wheatstone's and so many of his followers, but in this apparatus the maximum result of alternating currents is more attainable, much limited in Wheatstone by their varying length necessary to produce the dot and dash of the Morse Alphabet.

The apparatus is arranged to be worked duplex, and for this purpose Mr. Olsen has constructed a rheostat and condenser in one, of which, however, I have no description.

BAUDOT.

The Baudot apparatus exhibited in the French section at Paris is constructed so that there are five communications through one wire; that by Schaeffler in the Austrian has four.

The various apparatus are fixed on one large strong counter, and are so arranged that the key-board for each clerk is as close as possible to the type-recording receiver, which corresponds to the line of communication. (See Fig. 3, Plate 2).

Each key-board (or manipulator) consists of five keys, each key when at rest is connected with the negative pole, and when depressed, with the positive pole of the line battery, the centre of which is to earth. The manipulation of these five keys allows of 31 combinations.

At each station there is a distributor (Fig. 4), in some respects on the same principle as that in Meyer's instrument, the description of which is to be found at page 862 of the "Electric Telegraph," by Prescott. The body of this consists of an ebonite cylinder,

arranged, with five rings of brass contact-makers encrusted on and let into the ebonite; all the wires from the five key-boards lead into the end of the drum, whence also proceed the various wires to other parts and to line. The circumference is divided into six sectors, one small one used for correcting synchronism, and five large ones used for sending and receiving; each of these sectors is divided (see Fig. 3, which shows the surface of one sector in plan)—

A first, row of five contacts, $l^1 l^2$, etc., for the local work.

A second, row of five contacts, $E^1 E^2$, etc., for receiving.

A third, row of five contacts, $L^1 L^2$, etc., for sending.

A fourth, one single contact through all the sectors, completes the sending circuit.

A fifth, one single contact through all the sectors, completes the receiving circuit.

These last two are switched into circuit by the operator for sending and receiving.

In Schaeffler's apparatus there are four circuits, and in his key-board the five keys are worked on with an alphabetical key-board like in an ordinary Hughes, saving the clerks having to carry the combinations in their memory.

The 25 contacts of the first row thus correspond with the five key-boards, and through them the active currents from each key pass to line.

The 25 contacts of the second row are connected with the "combiner" at the station.

Those of the third row are used to work the local type-printing discs, and record the signals sent.

The revolving limb A, which carries the contact rubbers (see Figs. 3 and 4), is attached to a hollow axle, borne on the main axis of the instrument, and is moved by powerful clockwork which causes it to travel round the drum, the path of each of the contact rubbers being on the face of the ring which it serves.

The rubbers are connected electrically in pairs. See Fig. 3.

The first connects row marked l with E .

The second, row L with the sending row.

The third, row E with the receiving.

At each station the clockwork above referred to, carries the limb of the distributor slightly in advance of its time, and as it passes underneath, this error is corrected by the action of an electro-magnet, which receives its impulse from the current carried by that sector of the drum already referred to: thus a perfect synchronism of the revolving limbs of the distributors at each station, at one position in each revolution, is established.

Without more illustration a reader cannot possibly identify all the parts of this portion of the apparatus, but he will understand that its object is to secure that at the same instant of time the contact rubbers at each station shall arrive at the corresponding contact points of each series.

Each of the operators at the sending station presses the keys necessary to send the series of currents required to produce the combination (described further on) at the receiving station. As the limb passes over the series of contacts on the distributor drum which belongs to the key-board worked by each clerk, the combination of each is sent to line, and regularly in succession received on the distant station. No keys are pressed, nothing passes while the corresponding series is under the limb; if the keys are pressed at irregular intervals, no irregularity in transmission occurs, because the transmission only takes place during that one position of the limb.

The reader who does not care to follow the details, will understand that this limb which is whirling round the drum, is sending currents to line in combinations of five, which are travelling to the distant station as fast as they can be received at the other end, without merging into a solid current.

It is already understood that these are received at the distant station on a similar distributor, which, when acting as a receiver, passes the currents in precisely the order they have been received by the corresponding contacts to five groups of five small polarised electro-magnets (1, 2, &c., Fig. 3). The arms of these relays, it is needless to say, maintain the contact made by the last current which has been received by the distributor, and each group of five, after each revolution of the receiving contact rubber of the limb, remains *in statu quo* until the sending station sends another set

of currents to group the arms of the corresponding five relays in a fresh combination.

It will be recollected that the keys at the sending station, when at rest, cause a negative current to pass to line, therefore it will follow that, until disturbed, the five relay arms will all lie the same way; negative currents will not therefore move them, except they have been left on the positive contact in the transmission of the previous combination.

The receiving apparatus special to each of the five lines of communication consists, as has been said, of a set of five commutating electro-magnets and a combiner (Fig. 5), with a type-printer attached.

The combiner is constructed as follows:—A fixed ebonite drum carries five rows of brass encrusted contacts; round this travels a limb B (Fig. 5) which is on the same axle as the type wheel, bearing five contact rubbers, the contacts of which are in the same straight line parallel to the axis of the drum. In Fig. 3 the face of the drum is shown in plan.

The contact makers occupy three quarters of the face of the drum, the remaining quarter presenting a surface of plain ebonite; in each ring the contacts are insulated, but alternatively connected with the plus and minus contacts of the relays, $a a'$ $b b'$, &c., each relay serving one ring.

Thus, in the first ring which has 16 contacts, eight lead to the plus contact, and eight lead to the minus contact of No. 1 electro-magnet.

In the second ring which has 9 contacts, five lead to the plus, and four to the minus contacts of No. 2, and so on.

It will now be easily understood that, as the limb with the five rubbers revolves round the drum, there will be only one position in which it will complete the local circuit through the contacts on the drum and the relays, for each combination of the latter, and how, at that moment, the printing lever C will strike up against the type, and record the character.

As a negative current is always passing to line, the transmission of each character requires at most three changes of current from minus to plus:

Thus C is transmitted by + — + — +

Diagram
Explanatory of Baudot No 1.

Fig. 3.

Contact rubbers on the revolving limb of the Combiner.

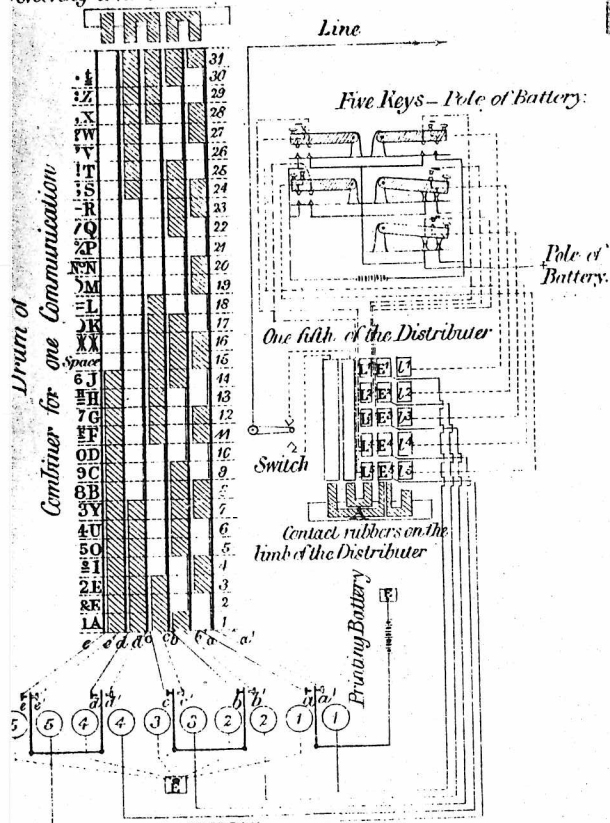
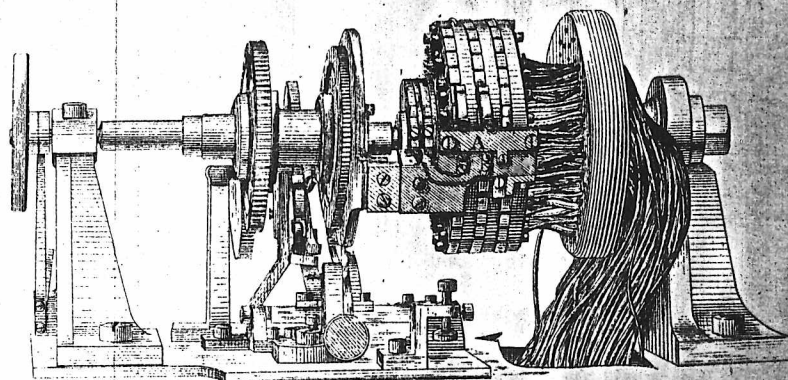
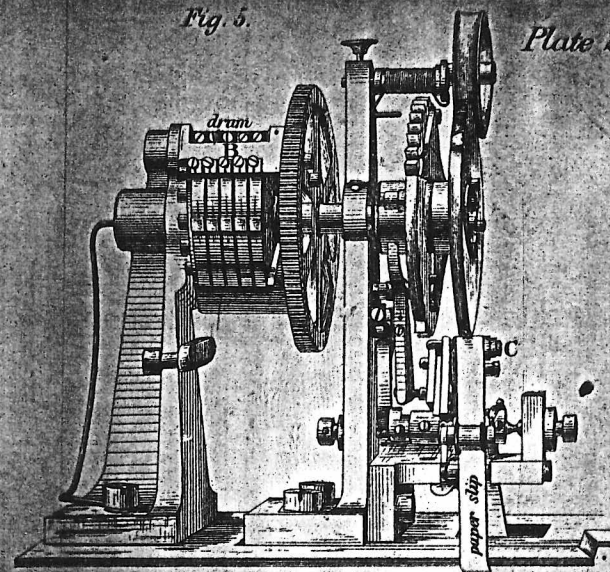


Fig. 4.



Distributor for five communications

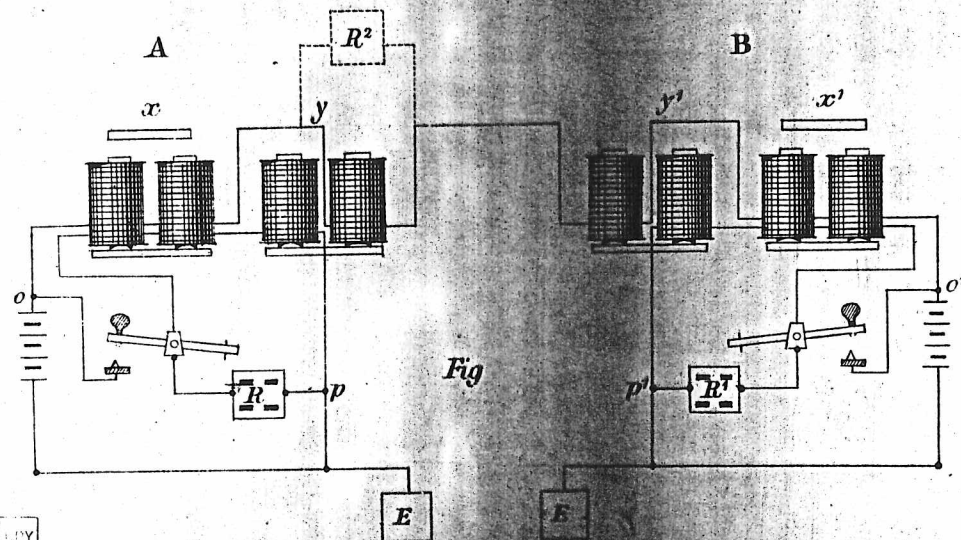
Fig. 5.



Combiner for one communication

Fig 2.

MANDROUX
Continuous current duplex.



Several letters only require one.

Thus A is transmitted by + — — — —

E is transmitted by — + — — —

so that each revolution of the distributor sends at most 15 currents and at least five.

When there are two or more currents of the same kind following one another, the impulse of the second and following currents is diminished, as in the Wheatstone transmitter, by an arrangement of the key, which reduces the strength.

Naturally, the rate of revolution of the distributor limb depends on the rate at which distinct impulses of current can be received at the distant station.

In actual practice, each impulse can be easily distinguished when it occupies only $\frac{1}{16}$ th of a second on a line of 630 kilometres in length; but as the limb travels at a uniform speed, its passage over each sector of five contacts must occupy about $\frac{1}{16}$ th of a second, which in practice allows of the limb making from 120 to 140 revolutions in a minute, and producing from 10 to 12 characters a second.

Owing more to the continual objections which he met with to his electrical combiner, and also in order to introduce several important modifications, besides reducing the number of points of electrical contact, Mons. Baudot constructed an instrument which he calls his No. 2 Form.

The alterations are very extensive, and show the genius of this very modest, clear-headed, and practical man, who is a bright example to telegraph operators in every country, he having commenced his study of Electrical Engineering a few years ago in the spare hours from his daily duty, and, having proved to the French Administration the value of his investigations, has had his time placed at his own disposal to perfect them, and labour and funds allowed to him.

No. 2 has at present only been constructed for a station with two circuits on the same wire, and this Mons. Baudot calls his unit.

The counter is a strong table, about 4' $\times$ 3', the key boards are at opposite sides, near the opposite ends, and the apparatus, con-

sisting of distributor, combiner, and the clockwork, is placed in the middle. (Fig. 6, plate 3.)

The first stage in simplification is in the distributor. Instead of a cylinder we have a flat ebonite disc A. Round its edge on the face are encrusted platinum contacts. Laid on this disc with coincident centre is a brass star (one ray lettered B), having the same number of rays as there are contacts. The axis of this is connected with line, each ray has a platinum contact on its under side, and they all turn upwards, so that pressure is required to make them touch the encrusted contacts underneath.

Contact is made by a limb C, which having the same axis, travels round, pressing down the rays by means of a little ivory wheel; the limb strongly resembles the grinding wheel of a mortar mill. At each station the little mills must travel synchronously within certain limits, to be described later on.

In the No. 2 we are considering there are 14 contacts, namely, five for each circuit, the remainder for the correcting current and to space between the series.

This is a single distributor. It is only required for receiving the currents from the keys and sending them to line. Owing to the use, in form No. 2, of only one electro-magnet in the receiver, a special distributing disc for it is unnecessary, and a distributor for recording locally has not been used, although it could be added.

The combiner (Fig. 7) for a pair of circuits, as just said, requires only one electro-magnet BB; this, influenced by the successive currents received through the distributor, causes an axle, A, which carries two upward turned hatchets, C, to give the latter a rocking movement.

As these currents arrive in two series, in each unit two hatchets are required. At this point the mechanical functions of the new combiner replace the electrical ones in the No. 1.

The arrangement is in duplicate, one over each hatchet. (Only one is shown in section in Fig. 7.)

Five small steel forks, D, stand vertically over the hatchet. Five cams, E, revolving by the local clock-work carrying projections at α , cause the forks to descend, first in succession, and then altogether.

once in each revolution, after which they rise by the force of a resisting spring attached to each.

The direction of the descent of each fork is guided by the position of the hatchet. Each has a projection (y) on one side, which only acts when a positive current places the hatchet so that the fork is pushed out of the perpendicular on the side of the projection, which then, in its descent, catches and depresses a corresponding projection, which appears out of a hole in the curved side of a small cylindrical (pin) box Z. This latter projection W is part of a small thin steel disc, toothed on the edge, of which there are five in the box, lying side by side, one for each fork. The toothings are so arranged that when the discs are laid one against the other, so that the projections coincide, there is no line found on the circumference of the cylinder thus formed, at which the toothings present a clear cut in the face, but when any one, or combination, of the projections is moved, the toothings will at once present a clear cut.

In the cylindrical (pin) box, and round its circumference, stand 31 small steel pins, F, which project through slots on one flat face of the box, and which, by means of springs, press against the toothed edges of the discs (springs and projecting ends not shown).

At each combination of the toothings on the discs, a pin falls forward into the cut, and its projecting point comes in the way of a little limb which travels round on the face of the box within the circle formed by the projecting points of the small steel rods, and moved by the clockwork, somewhat similar to the sledge on the rotating axis in the Hughes type printer (not shown). The impediment causes the limb to cant, and acting by means of an arm lever on a catch, frees a spring which brings the printing lever in contact with the type wheel; the printing lever immediately after resumes its normal position in the catch, pushed thereto by a cam on the printing wheel.

A further modification of the distributor, and a complete change in the combiner, has been made by Mons. Baudot in his Form No. 3, which may be considered his future working model.

The arrangement for having one counter for two operators is adopted, the distributor is separated as in No. 2, and may be

placed by itself on a table apart; it is increased in capacity, and can distribute to and from 3 such counters or 6 operators at each terminus of a wire; being arranged so that a conductor may be worked singly or sextuplex. The distributors then have their own clock-work. The distributor which in No. 3 is of the same altered form as that described for No. 2, has $5 \times 6 + 12 + 2 = 44$ contacts, 5 for each of the 6 operators, 2 between each series of 5, and 2 for the correcting current. The mill wheel limb travels round as described, pressing down the 44 rays of the contact star.

Three of these distributors are used—one for sending, one for receiving, and one for the local recorder, when that is used.

Synchronism of movement at the two stations is, as has already been explained, obtained by the passage of a correcting current, which, acting on a local, delays the travelling limb, which may be in advance of the other at the end of each revolution, but a further improvement is effected in No. 3, which avoids all chance of irregularity of movement between considerable limits, such as might cut off too large a portion or the whole of a signal. It is found that contact during only $\frac{1}{4}$ th or $\frac{1}{8}$ th of the time of passage of the mill wheel limb is necessary to transmit the line current, and, therefore, the limb carries on its end a small ratchet discharger, which derives the line current to earth except during a fraction of the passage of the wheel, and by which that fraction of current to the combiner can be made to take place at any instant during the passage.

It is obvious then that all trouble as to inaccuracy in the synchronous movement of the travelling limb at each station is quite avoided.

Six series of 5 wires are led from each distributor to the three operating counters. Each operating counter has its own clock-work, its combiner, with two printing wheels and two key-boards. Again, in No. 3 as well as in No. 2, we find a mechanical arrangement replacing the electrical one in No. 1.

The one electro-magnet and two combiners in No. 2 are replaced by five electro-magnets and one combiner.

The five electro-magnets are wound for intensity, and are connected to two contacts on the receiving distributor—No. 1 magnet

to No. 1 contact first series and No. 1 contact third series, and so on.

Contact completed at the distributor, the line currents pass through the coils to earth, but, at the moment before the mill wheel releases the contact ray, a local circuit through the electro-magnet just affected by the line current is closed. The work of these two currents on the electro magnet is as follows:—Each electro-magnet has a keeper, with a spring to release it. The local current powerfully attracts the keeper, and there is enough residuum to continue the attraction. Each negative current leaves the keeper attracted, but each positive releases the keeper, which strikes upwards in the act, to be re-attracted by the immediately following admission of the local battery.

In place of two combiner boxes there is one disc combiner, constructed as follows (Fig. 8):—

One face of a brass disc, which is about 3 inches in diameter, is ploughed into 10 concentric grooves, which are divided into deep or shallow sections, the number and length of which in each groove agrees with the rule by which the combinations in each of the three systems are obtained. At one line of radius H I of these concentric circles the divisions between five alternate grooves are obliterated for about $\frac{1}{4}$ th inch, and at the same places five little studs K project through slot holes into the grooves from the back of the disc; each little stud belongs to one of five levers, which when moved at the further end moves the stud in the slot. The play of these studs when moved is just sufficient to change or shunt the direction, from right to left, and *vice versa*, of any object travelling round in the grooves.

There are five such points or fingers L which press into the bottom of the grooves, on each of two limbs M N which travel round the face of the disc, one limb for each circuit, and these fingers each have two grooves, into either of which they are shunted as described.

The shunting levers are connected by a beautiful and simple reciprocal movement with five little rods; each rod is end-on to the keepers of the five electro magnets. These keepers when released, as already described, by the incoming positive currents, spring against and strike the rods, which guide the five little shunts, which

thus assume a fresh combination of positions as each set of currents arrive, and are ready to guide the fingers into the corresponding grooves on the disc. In due course each limb which carries the fingers, and which is moved by the local clockwork in its revolution, reaches the radial line at which the ten grooves merge into five, acted on or not by the shunting studs underneath, each finger continues in the same groove or enters the next one, and then travels on with its fresh combination until the radial line is reached at which no section of shallow grooves is encountered by the fingers. As they act as one in this direction, they all fall into the deep grooves for a moment, and the limb in changing position acts on a catch which frees a spring, which, as in No. 2, brings the printing lever in contact with the type.

In comparing his with a Wheatstone automatic apparatus worked duplex, Baudot claims the following superiority:—

1st. He saves the time given to perforating and writing down the message.

2nd. He also saves the labour, two operators sufficing for each line of communication.

3rd. He saves the errors in punching and writing-out.

He claims equality electrically, as both systems send continuous currents, and both reduce the current for continuous emission of the same kind.

He admits inferiority on the subject of the synchronism, but claims that his precautions preclude almost all possibility of error.

In his No. 3, his arrangement of counters is considered very convenient, the counter carrying the distributor might be in charge of one operator to watch it, but in fair states of lines, could be left alone for hours, the separate clockwork for the distributor and for each operating table is also convenient.

In No. 3, he arrives at 150 to 180 revolutions of the limb a minute, this gives 900 to 1,280 characters, which, at 150 characters to the message, produces the enormous result of 360 to 500 messages an hour.

There is no pretence on Mons. Baudot's part that such work has yet been done, because his No. 3 form is only still in course of construction, at the works of Dumoulin Froment, at Paris, but from

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the practice over a long time on working lines of considerable length, which he has had with his first forms, there seems to be little reason to doubt a very astonishing measure of success.

SCHAEFFLER.

It would be impossible to describe in detail the wonderful multiple telegraph exhibited by Mons. Otto Schaeffler, within the time I have at my disposal, but I can place the meeting *au courant* of its principal features in a few words.

The apparatus itself standing on one massive table with strong cast iron supports, is a marvel of design, in which the proportion of strength of each part bears evidence of careful thought.

As already stated, each of the four manipulators use an ordinary alphabetical key-board, which by mechanical transmission acts on the five keys, which Baudot's manipulates with the fingers.

These keys at rest no current goes to line, but when depressed, altogether or in groups, currents are sent to a distributor, the office of which, as in the Baudot, is to send them successively to line. This distributor is (Fig. 1, plate 4) in the shape of a disc of ebonite, on which revolves on an axle, having the same centre, a limb Z provided with three rubbers, the two inside of which are connected electrically with one another, and not with the outer one.

On the disc are encrusted three rows of contacts. In the outer there are five line contacts in each quadrant, besides some others; in the middle one, also, five in each quadrant, each connected to what Schaeffler calls his permutation relays, R_1, R_2 , &c. The inner is composed of a metal ring which is connected with one pole of the local battery, the other pole being to a relay which closes the local with each line current.

The object, then, of the line currents passing through a distributor and a local relay at each station, and then to earth, is, to move the armatures of the five permutation relays of each communication. The armatures of the relays (which in Baudot are polarised) are restored to their normal position when the current has done its work, by a mechanical action somewhat

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SIXTH EDITION, REVISED AND ENLARGED.

WITH 670 ILLUSTRATIONS.

IN TWO VOLUMES.

VOL. II.

NEW YORK:
D. APPLETON AND COMPANY.

1885.

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not by pages

CHAPTER XXXVIII.

SIMULTANEOUS TRANSMISSION IN OPPOSITE DIRECTIONS.

THE various methods which have been devised of simultaneously transmitting two or more communications in the same or opposite directions over a single wire, including the duplex, quadruplex and other similar combinations, may be appropriately classed under the general head of multiple telegraphs. The possibility of making use of a single wire for the simultaneous transmission of two or more communications seems to have first suggested itself to Moses G. Farmer, of Boston, about the year 1852. He proposed to employ two rapidly revolving synchronous commutators, one at each end of the line, which would serve to bring the latter successively and simultaneously into connection with two or more short branches at each terminus, in each of which ordinary telegraphic apparatus might be inserted. Thus the current in the corresponding branches at either station, though apparently continuous, would actually be composed of rapidly recurring synchronous pulsations. From the difficulty of maintaining synchronism between the corresponding instruments and other causes, nothing of practical value resulted from the invention, though successful experiments were made on a small scale on one of the municipal lines of Boston in 1852. The same idea, however, has more recently been carried out by Meyer, who exhibited at Vienna, in 1873, an apparatus upon this principle capable of transmitting four simultaneous communications, which will be described hereafter.

The methods of multiple transmission which within the past few years have proved to be of so much value in practical telegraphy, are based upon an entirely different principle from the above, which may be properly considered an outgrowth of the invention of Dr. Wilhelm Gintl, Director of the Austrian State Telegraphs in 1853—an invention which directed the labors of

both European and American inventors into a new and fruitful field.

The different methods or processes of multiple transmission may be conveniently classified as follows:

1. The simultaneous transmission of two communications in *opposite directions*.
2. The simultaneous transmission of two communications in *the same direction*.
3. The simultaneous transmission of four communications, *two in each direction*.

The simplest of these processes and the earliest to be successfully employed in practice, is that first mentioned, viz., simultaneous transmission in opposite directions. The conditions to be fulfilled in practically carrying out this method of telegraphy are—first, that the receiving instrument at the home station shall remain entirely unaffected by the movements of the transmitting key at that station, while at the same time it shall remain free to respond to the currents transmitted by the key at the distant station; and second, that the in-coming currents from the distant station shall always be provided with an uninterrupted passage to the earth, through the apparatus of the home station

GINTL'S METHOD.

As previously stated, the first effort in the direction of a practical solution of the problem in question was made by Dr. Gintl, whose experiments were performed on the line between Prague and Vienna in July, 1853. In Gintl's method the first condition was fulfilled by the use of a differential relay—that is, a relay whose helices are composed of two distinct wires, one of which is traversed by the main line current, and the other by that of a local or equating battery. These coils, wound in opposite directions upon the cores, when connected in their proper circuits, exert equal and opposite magnetic effects upon the relay, so that when the key is depressed, although the entire current of the main battery passes through one wire of the relay, it still remains perfectly unaffected. In order to close the circuit of

the main and equating battery at the same instant a double key is used, consisting of two separate levers insulated from each other, connected together by an insulating cross-piece, and having in front a common knob. Fig. 461 is a plan of Gintl's arrangement; $a b c$ and $a' b' c'$ represent the double key. The equating circuit I II, represented by dotted lines, passes through one wire of the relay (usually the outer and thicker). It includes a local battery, and is opened and closed by the key at $a b$. The front contact of the other side of the key is connected to the positive pole of the main battery L B, the negative

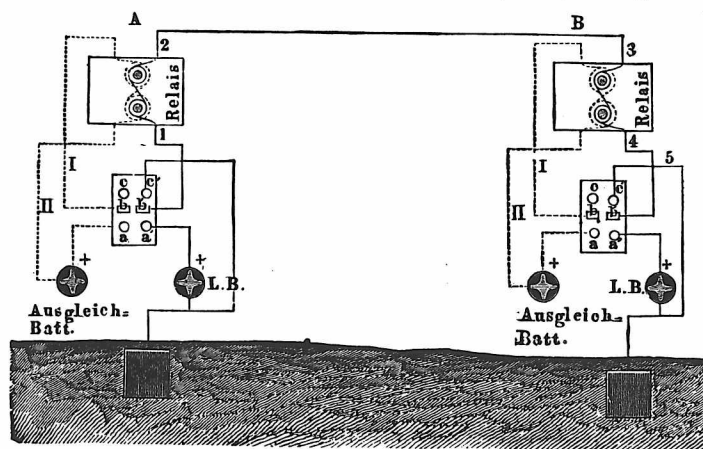


Fig. 461.

pole being to earth. The middle contact or key axis b' is connected to the other coil of the relay by the wire 1, and thence to the line wire at 2. The rear contact c' of the key is connected directly to the earth.

By inspecting the connections it will be seen that when the double key at station A is depressed, the current of the main battery at that station is sent to line through one wire of the relay, while at the same instant the circuit of the equating battery passes in the opposite direction through the other wire of the

relay. If, therefore, the strength of the equating current has been properly adjusted, the effect of the current transmitted to line will be entirely neutralized, as far as its action upon the home relay is concerned.

If, now, while the key at station A is transmitting a current to the line, that of station B is also depressed, the main battery at B is put to line with its poles reverse to that of the battery at A, and the current of the main line disappears. Thus the equilibrium previously established by the equating battery is destroyed, and the relay at A will give a signal corresponding to the time the key at B remains depressed. During the whole time that the key is kept down at A the relay at B will respond, whether the key at B is depressed or not, because, as we have seen, the effect of B's own current upon his relay is neutralized by his equating battery. If, therefore, both stations work their apparatus at the same moment, the respective relays will respond properly thereto.

There is, however, one position of the apparatus in which the signals transmitted from one station are not perfectly received at the other. This is when, during the manipulation at either station, the lever of the key is removed from the back contact $c c'$ until it touches the front contact $a a'$, or *vice versa*. In these cases the main circuit is momentarily interrupted at b , interfering with the signal which should be given by the relay at the same station. Thus, the second of the two conditions referred to is imperfectly fulfilled by this apparatus. In practice it was also found to be a great and insuperable difficulty to maintain the balance between the main and equating circuits for any length of time.

FRISCHEN'S METHOD.

An important improvement upon Gintl's method was invented early in 1854, by Carl Frischen, an inspector of telegraphs in Hanover, and which is in a great measure free from the objections which proved fatal to the practical success of its predecessor. As Frischen's invention is the basis of

some of the most successful methods of duplex telegraphy now in use, its construction and the principles of its operation will be explained in detail. Fig. 462 is a diagram showing the arrangement at one of the terminal stations, the other, of course, being a duplicate of it. R is the receiving relay provided with two separate coils, so arranged that when equal currents pass through them they will exert an equal and opposite magnetic effect upon the cores, and thereby neutralize each others. One pole of the main battery B is connected to the earth, and the other to the front contact 1 of the key K. The back contact 3 of the key is connected directly to the earth, while to the lever

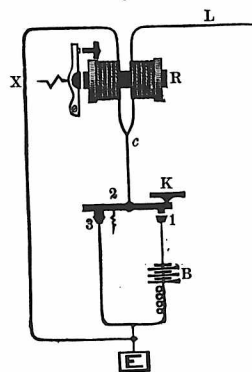


Fig. 462.

2 is attached a wire which divides at *c*, one branch going through the right hand coil of the relay to the line *L*, and the other through the left hand or opposing coil, and thence to the earth. It is obvious that by making the resistance in the two branches which diverge from the point *c* exactly equal, a current can be sent to the line by the depression of the key *K* without affecting the relay *R*. This may be accomplished by inserting a rheostat at *X*, in the left hand circuit, which for convenience may be termed the artificial line. Fig. 463 is a complete plan of the arrangement at both stations, which are distinguished by the letters *A* and *B*. The main batteries *L B* at each station are

placed with their $+$ poles to the line and $-$ poles to the earth. *R* and *R'* are the receiving relays, each wound with two separate coils, as before explained. The rheostat, *W* or *W'*, in the artificial line at each station, must be so adjusted as to make its resistance exactly equal to that of the line *A B* added to that of one wire of the relay at the distant station.

If now the key at station *A* is depressed, the current from the main battery *L B* will divide at the point 3, one portion going by way of 4 and 6 to the line, passing through one coil of the relay, thence from the line through one coil of the relay at the

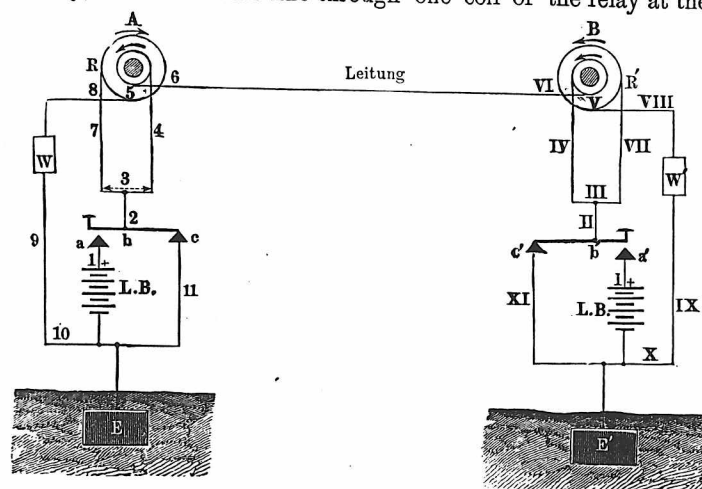


Fig. 463.

distant station *B*, by way of *VI* and *IV*, thence by *III* and *II* to the key lever at *B'*, back contact *c'* and wire *XI* to the earth, the other portion going from 3, in an opposite direction, through the home relay by way of 7, 8, rheostat *W* and wires 9, 10 to the earth. These two branches of the current will be equal to each other, as before explained, and will produce no effect upon the relay at *A* for that reason. The relay at *B*, on the other hand, will be affected by the current coming from *A*, and will respond to the movement of the key at the latter station.

Thus, in this arrangement we would have, under the conditions stated, an effective force acting upon the armature n s, varying from 0.70 to 0.95. It will at once be seen that this margin enables the operators to work freely over escapes and changes of resistance in the line. Thus, in the case cited, in order to disturb the balance of the sender's relay, so as to give him back his own signals, the resistance of the line must be diminished sufficiently to increase the strength of current from 0.35 to 0.71—more than double—which would require a very heavy leakage. In practice, the resistance of the rheostat r is made a constant quantity, all necessary adjustments being effected precisely as in an ordinary instrument, and with no more inconvenience.

The Stearns condenser c may be applied when necessary, in the manner shown in the figure, for the purpose of neutralizing the static discharge.

EDISON'S METHODS.

A method of simultaneous transmission, invented by T. A. Edison of New Jersey, in 1873, is shown in fig. 489. Its peculiarity consists in the fact that the signals are transmitted in one direction by reversing the polarity of a constant current, and in the opposite direction by increasing and decreasing the strength of the same current. The relay R at station A consists of two soft iron electro-magnets r_1 and r_2 which act upon the same armature lever, thereby closing the local circuit of the sounder or other receiving instrument in the usual manner. The transmitter T is operated by a key and local battery as in Stearns's method, and is so arranged that when the key is in a position of rest the negative current from the battery E_1 passes to line through the electro-magnet r_2 of the home relay R , but if the key is depressed the lever T of the transmitter makes contact between the battery E and the earth, and at almost the same instant interrupts the previously existing contact between E_1 and the earth; thus there is at all times either a positive current going to line through r_1 , or a negative current through r_2 .

At station B the currents pass through a polarized receiving instrument R_1 , and thence through a rheostat X to the earth. The tension of the spring of relay R is adjusted so that the current going to line is not sufficient to overcome it except when the rheostat X is cut out by depressing the key K at station B . Consequently A sends to B by reversing the polarity of the current without changing its strength, while B sends to A by changing the strength of the current irrespective of its polarity.

The polarized relay can be placed at a number of stations on the line, and each will be able to receive the signals from the stations transmitting the positive and negative currents. A neutral or Morse relay may also be placed at a number of stations,

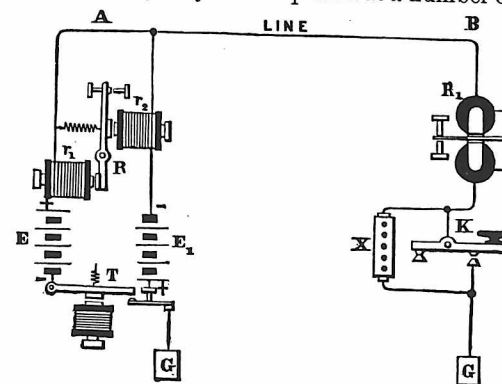


Fig. 489

if devices are applied to prevent the mutilation of the signals by change in the polarity of its iron core.

The principle embodied in this invention, as we shall hereafter see, has been successfully employed in quadruplex transmission by the introduction of suitable modifications in the arrangement of the apparatus.

In 1874 Edison invented a method of simultaneous transmission by induced currents, which has given very satisfactory results in experimental trials. The arrangement of the apparatus differs from Stearns's in that a compound differential induction coil $I_1 I_2$ (fig. 490) is substituted in place of the home relay; the middle or secondary coil I being connected to a polarized re-

ceiving instrument R. The out-going currents divide between i_1 and i_2 , and as these oppose each other in their action upon the iron core, no induced current is set up in I. The in-coming currents pass through i_1 alone, and thus an induced current is generated in I at the beginning and end of every signal which operates the polarized receiving instrument R. The latter may be either a relay or an ink-writer.

It would require too much space to refer in detail to the great number of minor modifications which have been made in the different methods of simultaneous transmission in opposite direc-

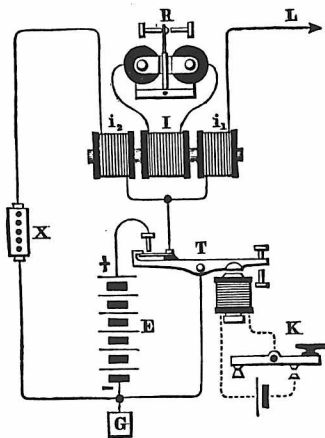


Fig. 490.

tions, both by European and American inventors. It is believed that every invention of the kind possessing any essential novelty has been explained with sufficient clearness to give the reader a correct comprehension of the subject, both in general and in detail. The system, in some form, is now in use on the more important land lines in nearly every country in the world, and the adaptation of it to submarine lines also has thus far been quite successful. In the United States the duplex has since 1874 been largely superseded by the quadruplex method, which has now been brought to great perfection, and will be described at length in a succeeding chapter.

CHAPTER XXXIX.

SIMULTANEOUS TRANSMISSION IN THE SAME DIRECTION.

THE success of the ingenious invention of Frischen, in 1854, was sufficient to give an entirely new direction to the minds of many enterprising European electricians, and during the following year the problem of simultaneous transmission in the same direction, which naturally suggested itself as the next step in the progress of invention, was solved with more or less success by the independent labors of a number of different inventors.

In any system of simultaneous double transmission in the same direction, two keys are required at the sending station, and at least four different electrical conditions of the line must be provided for, one for each of the four following cases:

1. When the first key is closed and the second key open.
2. When the second key is closed and the first key open.
3. When both keys are closed.
4. When both keys are open.

The methods of Stark and Siemens, though differing in detail, were arranged upon one general principle, the four electrical conditions of the line being as follows:

1. A positive current having a strength of 1.
2. A positive current having a strength of 2.
3. A positive current having a strength of 3.
4. No current.

STARK'S METHOD.

The first attempt made in this direction was by Dr. J. B. Stark, of Vienna, in 1855. His method consists of sending from the transmitting station, by two keys, two currents of different strength, which on arriving at the receiving station, each set a relay in motion.

The relays are arranged in such a way that, when the weaker currents traverse the line, only one of them responds; when the stronger current traverses the line, the other relay alone responds; and lastly, when both currents go together, both the relays respond to them.

At the sending station Stark arranged two keys as in fig. 491; *K* being a simple Morse key, and *K'* a similar lever, supplied at the back with an insulated earth contact, which it moves against the two anvils 5 and 6. The usual front and back contacts of the keys are marked in the figure 1 and 3 respectively, and the levers 2. The battery is divided into two unequal parts, *b* and *c*, the number of elements represented by *b* being double that of

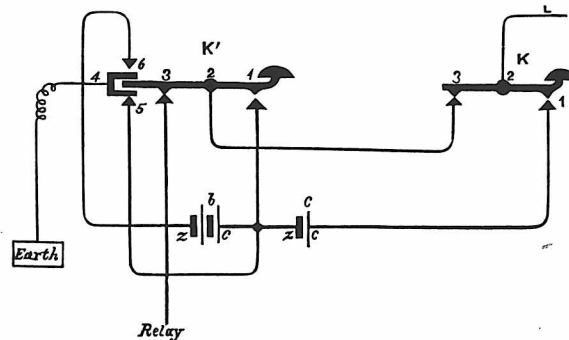


Fig. 491.

c. The battery *c* is put into circuit with the line by pressing down the key *K*; *b*, by the key *K'*; and both together by depressing both keys at the same time.

The copper pole *c* is, therefore, connected to the contact 1 of *K*, the zinc pole of same to 5 of *K'*. Copper pole of *b* is connected with 1, and zinc pole with 6 of *K'*. The lever of *K'* is in connection with the back contact, 3 of *K*; the line is brought to the lever 2 of *K*, and the back contact of *K'* goes to the relay, etc.

When *K* alone is depressed, the currents of *c* pass from *z* (5 and 4 of *K'*) to earth, and from *c* (1 and 2 of *K*) to line.

When *K'* is depressed, the currents of *b* pass from *z* (6 and 4 of *K'*) to earth, and from *c* (1 and 2 of *K'*) to line.

When both *K* and *K'* are depressed, the united currents of *b* and *c* pass from zinc of *b* (6 and 4 of *K'*) to earth, and from copper of *c* (1 and 2 of *K*) to line.

By the depression of one or other or both the keys at the sending station, three different strengths of current are therefore produced, which are in the relation of 1, 2, 3. These currents we will call *S*, *S*₁ and *S*₂.

At the receiving station all currents pass through relays I and II, fig. 492. A common local battery, *E*₁, serves both these instruments; its zinc pole being connected with the lever of each

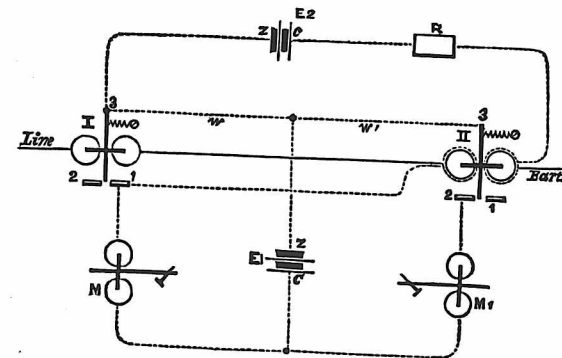


Fig. 492.

of them, and its copper pole with their metal contacts. The relay II is furnished with outer coils, which are put into circuit with another local battery *E*₂, and a resistance *R*, by means of the lever of relay I.

The lever of relay I is held on its insulated contact by a spiral spring, whose force is adjusted so that the currents *S*, or those of the portion, *c*, of the battery, are unable to move it, but so that it is easily moved by *S*₁ and *S*₂—the currents of section *b* and the whole. Relay II, on the contrary is adjusted delicately, so as to respond to the weaker currents.

When, therefore, the key K at the sending station is pressed down, the current of c is sent through the line, and passes through the coils of relays I and II to earth. Relay I is unaffected, but relay II is put in action, and the register or sounder M_1 , in the local circuit (E_1 , z , relay II, 3 , 2 , M_1 , c , etc.), records whatever signals are given by K .

When K' is depressed at the sending station, current S_1 is transmitted, and the lever of relay I deflected against the local contact. Thus two local circuits are closed; the first is that including the battery E_2 , R , and the extra coils of relay II, by which the action of the line current in this relay is counteracted, and the lever held still against the insulated contact; therefore M_1 does not respond to these stronger currents. The second local circuit is that of the sounder or register M and battery E_1 .

The intensity of the counteracting battery E_2 , whose magnetic effect upon the armature of relay II we will call S_2 , is regulated by the interposed resistance R , until it balances the magnetizing power of the line current sent by K .

The third case is that in which, during the manipulation of the two keys, both happen to be pressed down together. When this occurs the current S_2 of the whole battery goes through both the relays I and II. Relay I is put in action as before, and closes its local circuit and that of the counteracting battery E_2 . But as the opposite magnetic effect S_2 of the extra coils of relay II is only equal to that of S_1 , and since S_2 is equal the sum of S and S_1 , it is evident that the relay II will be acted upon by the difference of the magnetic effects due to the line and the counteracting currents, or by S , which is precisely the same as that produced when K alone is depressed. The register or sounder M_1 will therefore also be set in motion. Other arrangements were also invented by Stark for telegraphing in the same direction at the same time to different stations along the line, both directly and by translation.

Siemens's method, which is very similar to that of Stark, was invented at nearly the same time.

There are two serious difficulties, leaving minor ones out of

consideration, which are inherent in every system of simultaneous double transmission in the same direction. In the first place, when either key is passing from its front to its rear contact, it causes a momentary interruption of the signal which is at the same time being transmitted by the other key. The second difficulty is a still more serious one, and arises in the following manner: In the simultaneous operation of the apparatus there must, of necessity, frequently be a change from a positive to a negative condition, or *vice versa*, of the line, or at least of the relays or receiving instruments, consequent upon the movement of a single key; yet it is evident that the reversal of the magnetic polarity of a receiving instrument by the action of one key must interfere with a signal which is being given upon it at the same time by the action of the other key. This difficulty is met with, in some form, in every possible arrangement of the receiving instruments. Neither Stark nor Siemens suggested any method of remedying these serious defects, and judging from his published paper on the subject, the latter evidently considered them insurmountable.

It is evident that Dr. Stark, even at this early date, clearly saw that the successful solution of the difficult problem of simultaneous transmission in the same direction included as a necessary consequence the solution of the problem of quadruple transmission also; for a knowledge of the invention of Gintl, as perfected by Frischen, was all that was needed to show that it was equally applicable either to a single or a double telegraph in one direction.

In the first published description of his method, dated at Vienna, October 31, 1855, Stark concludes as follows:

"With the method of double transmission in the same direction we may also combine that of counter transmission (*gegen-sprechen*), and hence arises the possibility of simultaneously exchanging four messages upon one wire between two stations, which will, however, hardly find any application in practice."

This is unquestionably the earliest published suggestion of what is now known as the quadruplex system.

KRAMER'S METHOD.

The method invented by Kramer, shortly after the above described method of Stark had been made known, accomplished the desired result by means of another and better arrangement of currents for the different positions of the keys, as follows:

1. A negative current having a strength of 1.
2. A positive current having a strength of 2.
3. A positive current having a strength of 1.
4. No current.

To avoid the interruption, which in Stark's method was caused by the movement of one key while a signal was being given by the other, Kramer made use of a device originally invented by Gintl (fig. 467, page 779), viz., that of keeping the battery constantly on the main circuit, but shunted by the key, so that when

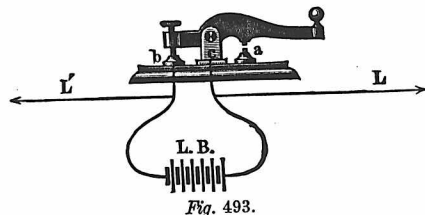


Fig. 493.

the latter was depressed the short circuit was broken and the current flowed to line, but when raised the battery was again short circuited.

Fig. 493 shows the manner in which the main battery $L.B.$ was connected with the key and the line wire $L.L'$. This plan effectually disposed of the difficulty in question, but was injurious in its effect upon the batteries, as these were kept closed on short circuit whenever the keys were at rest.

The arrangement at the receiving station is shown in fig. 494. The currents which arrive from the sending station pass successively through three separate relays R_1 , R_2 and R_3 , of which the armature levers only are represented in the figure. The armatures of R_1 and R_3 are polarized, so that the former responds only to negative and the latter only to positive currents of any

strength. R_2 , on the other hand, is a soft iron or neutral relay, but is adjusted so as to respond only to currents having a strength of 2. The arrangement of the registers or sounders M_1 and M_2 and the local batteries b_1 and b_2 will be understood by reference to the figure.

In a position of rest, when there is no current upon the line, the local battery b_1 is closed on short circuit, by way of relay levers a_1 and a_3 , and thus the register or sounder M_1 is cut out. The local circuit of M_2 is open at a_3 .

When the first key alone at the sending station is depressed, and a negative current having a strength of 1 is sent through the relays, R_1 only responds. This breaks the short circuit of the local battery b_1 at a_1 and M_1 responds.

When the second key alone is depressed, sending a positive current having a strength of 2, the relays R_2 and R_3 respond.

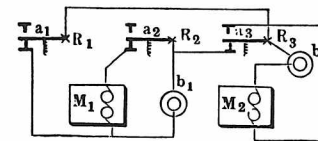


Fig. 494.

The local circuit of M_2 is closed by a_3 , but no effect is produced upon M_1 by the movement of a_2 .

When both keys are depressed simultaneously, a positive current of the strength of 1 goes to line, and the lever a_3 of relay R_3 alone responds, but this operates both M_1 and M_2 , the former by breaking the short circuit, and the latter by direct closing on its front contact in the ordinary manner.

If the first key is closed and the second key worked, the line current is changed from negative to positive every time the latter is depressed. As neither of these currents has sufficient strength to overcome the tension of the spring of the armature lever a_2 , this will remain at rest as in the diagram, while a_1 and a_3 move alternately. Thus the local of M_1 is constantly closed

through the back contact of a_2 , while M_2 responds to the movements of the second key.

Practically, the above method of operating a register or sounder by closing and breaking a shunt, is a very unsatisfactory one. It not only exhausts the local battery with great rapidity, but the demagnetization of the iron cores takes place with far less rapidity when the battery is cut off by a shunt, even of very small resistance, than when it is completely interrupted by breaking the circuit in the usual way, and this renders it impossible to receive and record the telegraphic signals with the rapidity that is necessary in modern telegraphy.

EARLY METHODS OF SIMULTANEOUS TRANSMISSION IN THE SAME DIRECTION.

In October, 1855, A. Bernstein, of Berlin, devised a plan for the simultaneous transmission of two messages in the same direction, which is shown in fig. 167. 405.

The transmitting apparatus consists of two independent circuit preserving keys K_1 and K_2 in connection with batteries B_1 and B_2 , the former composed of, say 10, and the latter 20 cells, as shown in the figure at station A.

The movements of these keys produce three different electrical conditions in the line, according to their respective positions with reference to each other, as follows:

1. First and second keys open. The route of the circuit may be traced as follows: From the earth plate G, through wire 6, adjustable stops 5 and 4, wire 3, to adjustable stops 1 and 2 and line L. This may be considered the normal condition of the keys, in which position no current passes to the line.

2. First key closed and second key open. The route is from earth plate G to wires 6, 7, main battery B_1 , thence to lever l_1 of key K_1 , and wire 3 to stops 2 and 1 and line L to distant station as before. In this position of the keys the smaller battery B_1 only is in circuit, sending to the line a positive or + current of + 10.

3. Second key closed and first key open. The route now is

from earth plate G, wire 6, to stops 5 and 4; thence by wires 3 and 8, to main battery B_2 , and lever l_2 of key K_2 ; thence by wire 9 to stop 1, and line L to distant office. In this position of the keys the larger battery B_2 only is in circuit, sending to line a positive or + current of + 20.

4. First and second keys both depressed. The route of the circuit in this case is from earth plate G, wire 6, 7, to battery B_1 , lever l_1 ; thence to stop 4, and wires 3, 8, and battery

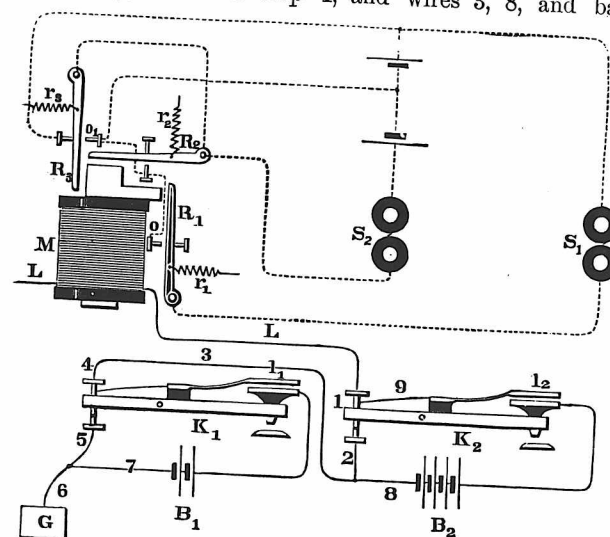


Fig. 495.

B_2 to lever l_2 , wire 9 to stop 1; thence to the line L and distant station as before. In this position of the keys both batteries are in circuit, sending to line a positive or + current of + 30.

At station B a receiving instrument or relay is made use of, composed of a single electro-magnet M, having three armatures R_1 , R_2 and R_3 , to each of which are attached retractile springs r_1 , r_2 and r_3 respectively, with local circuits and sounders S_1 and S_2 , as shown in the figure.

more securely by spring s_1 against stop P_1 , thus preventing a signal being given on sounder S_1 .

Armature a_2 of relay M_2 is carried from stop P_2 to o , because the strength of the line current, viz: -10 , added to that of the auxiliary local (-10), is sufficient to overcome the tension of retractile spring s_2 , thus breaking the shunt, and causing local battery l_2 to operate the sounder S_2 .

It will here be observed that when armature a_2 connects with stop o , the auxiliary local of relay M_3 is closed, the strength of which (viz: $+10$) being the same as that from the line, but of opposite polarity, it only serves to substantially neutralize the effect of the latter upon relay M_3 , and armature a_3 is held inactive by the retractile spring s_3 .

3. Keys K_1 and K_2 , both depressed.

A positive or $+$ current of $+20$.

Armature a_1 of relay M_1 is caused to move forward, thus breaking the shunt, and allowing a current from local battery l_1 to operate sounder S_1 . The line current in this case is of a polarity, and sufficiently powerful to completely neutralize the effect of the auxiliary local R_2 and exert a force upon relay M_2 , tending to attract its armature a_2 ; but the latter is held in the position shown, against stop P_2 , by the retractile spring s_2 .

The armature a_3 of relay M_3 is carried from stop P_3 to stop o_1 , because the line current is sufficiently powerful to overcome retractile spring s_3 , thus breaking the shunt and permitting sounder S_2 to respond.

Practically, the method of using one receiving instrument having three armatures is a very unsatisfactory one, for the reason that the effective attraction of the electro-magnet for any one of two or more armatures is materially lessened whenever one of the others is in contact, or nearly in contact, with its poles.

The manner of operating a register, or sounder, by closing and breaking a shunt, as in the system above described, would render it impossible to receive and record the signals with accuracy at any considerable degree of speed.

The use of three independent receiving instruments, though free from the objections just mentioned, does not obviate the difficulties which were inherent in the systems of simultaneous transmission in the same direction, invented by Stark and Siemens, in 1855, and which by the latter were considered insurmountable.

During the same year that Bernstein invented the methods of simultaneous transmission in the same direction, which we have described, Dr. J. Boscha, Jr., of Leyden, was engaged in the solution of the same problem. Boscha at first made use of three receiving instruments, two of them having polarized armatures, and the other a neutral armature.

To obviate a defect in this arrangement, caused by a reversal of the current upon the line, when a signal was being received upon the neutral relay, he subsequently devised the plan shown in fig. 497 in which all three relays are polarized. The operation of the transmitters K_1 and K_2 gives rise to three distinct electrical conditions of the line.

First: K_1 and K_2 both open. No current.

The armatures of the relays R_1 , R_2 and R_3 remain in the position indicated in the figure, the local circuit of battery e_1 is open, and a shunt being closed around the battery e_2 , sounders S_1 and S_2 are consequently inoperative.

Second: K_1 closed and K_2 open. Current = -2 .

This current causes R_1 and R_3 only to respond; the former, immediately after breaking the shunt around battery e_2 , closes the local circuit of battery e_1 , thus operating sounder S_1 . A signal upon S_2 is prevented by R_3 opening the local circuit of battery e_2 , at the same time that the shunt around the latter is broken by R_1 .

Third: K_1 open and K_2 closed. Current = $+1$.

This current causes R_2 alone to respond, thus breaking the shunt around local battery e_2 , and recording the signal upon sounder S_2 .

Fourth: K_1 and K_2 both closed. Current $+1 - 2 = -1$.

This current causes R_1 only to respond, which, by first breaking the shunt around battery e_2 , and then closing the circuit of battery e_1 , causes the respective sounders S_2 and S_1 to respond.

In 1861, Edward Schreder,¹ of Vienna, published the following description of his improved method for the simultaneous transmission of two messages in the same direction (fig. 498):

The transmitting devices consist of two continuity preserving keys, K_1 and K_2 , the operation of which gives rise to three distinct electrical conditions of the line, as follows:

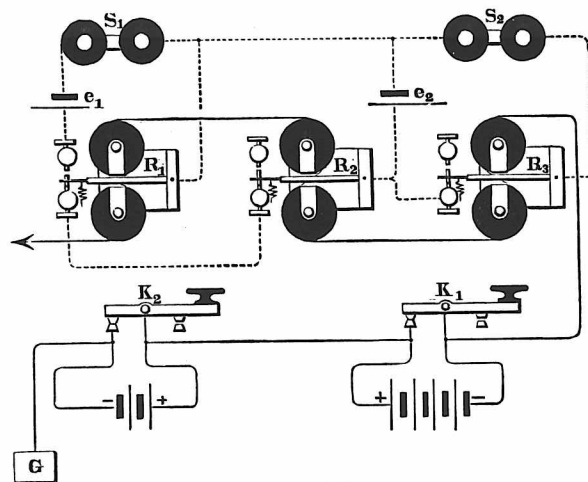


Fig. 497.]

First: Keys K_1 and K_2 , both open. No current.

Second: K_1 closed, and K_2 open. Current = - 2.

Third: K_1 open, and K_2 closed. Current = + 1.

Fourth: K_1 and K_2 both closed. Current = - 1.

At the receiving station Schreder makes use of two relays, one of which is provided with two polarized armatures, and the other

¹ Zeitschrift des Deutsch-Oesterreichischen Telegraphen-Vereins, herausgegeben in dessen Auftrage von der Königlich Preussischen Telegraphen-Direction. Redigirt von Dr. P. Wilhelm Brix. Vol. VIII. Berlin, 1861. Page 85.

a single neutral armature, the former being known as the Stöhrer relay, illustrated and described on page 542 of "Electricity and the Electric Telegraph."

Schreder also used a recording instrument, or sounder S_2 , wound differentially, which, together with the sounder S_1 were controlled and operated by the relays R_1 and R_2 , as hereafter explained.

It is obviously essential that sounder S_1 should respond solely to the movements of the key K_1 , and sounder S_2 to the move-

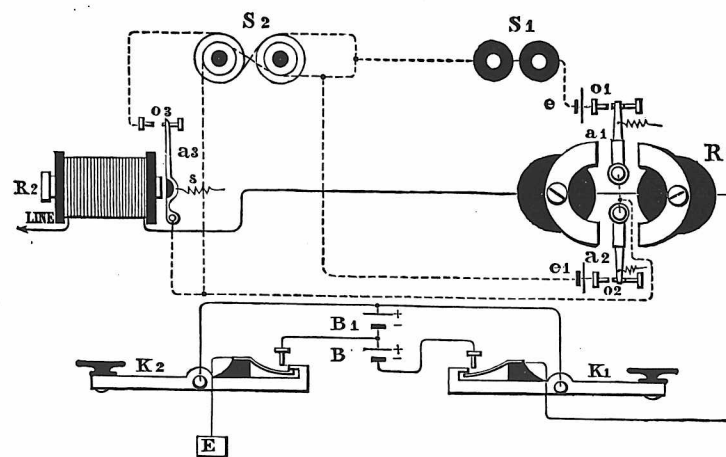


Fig. 498.

ments of key K_2 , while both S_1 and S_2 should respond when K_1 and K_2 are simultaneously depressed at the sending station. The manner in which this is accomplished will be understood by reference to the drawing, and the following explanation of the effect of the before mentioned electrical conditions of the line, upon the relays, at the receiving station:

First: K_1 and K_2 open. No current.

The armatures a_1 and a_2 , of relay R_1 , and armature a_3 of the relay R_2 , rest in the position shown. The local circuits being open, sounders S_1 and S_2 are consequently inoperative.

Second: K_1 closed, and K_2 open. Current = $-2B$.

The current in this case is of the right polarity, and of sufficient strength to actuate the relays R_1 and R_2 , causing armature a_1 of the former, and armature a_3 of the latter, to make contacts with their respective stops o_1 and o_3 , thus closing the local circuit of battery e , and sounders S_1 and S_2 . In order, however, that sounder S_1 alone should respond, it is essential that armatures a_1 and a_3 , of relays R_1 and R_2 , should move simultaneously, that is to say, a_3 should make contact with its front stop o_3 at the same time that a_1 , of relay R_1 , makes contact with its front stop o_1 , otherwise a false signal will be recorded upon sounder S_2 , around the cores of which two paths are provided for the current to pass, but by a simultaneous movement of the armatures a_1 and a_3 the current passing through sounder S_2 is divided, each half passing around its cores in opposite directions, thereby rendering the latter inoperative. Armature a_2 , or relay R_2 , is held more firmly in the position shown in the figure, the local circuit of battery e_1 remaining open between a_2 and stop o_2 .

Third: K_1 open, and K_2 closed. Current = $+B_1$.

The polarity of the current in this case is such as to cause the armature a_2 , of relay R_1 , to make contact with stop o_2 , thus closing the local circuit of battery e_1 , which, passing around one half only of sounder S_2 , causes the latter to respond.

Armatures a_1 and a_3 , of relays R_1 and R_2 respectively, remain in the position shown, thus rendering S_1 inoperative.

Fourth: K_1 and K_2 closed. Current = $-B$.

In this case armature a_2 , of the relay R_1 , remains in the position shown, the local circuit of battery e_1 being open at point o_2 . This current not being of sufficient strength to overcome the retractile force of spring s , of armature a_3 , the latter also remains upon its back stop. Armature a_1 , of relay R_1 , is, however, caused to move forward, and make contact with its front stop o_1 , thus closing the local circuit of battery e , which, circulating through sounder S_1 and one half of sounder S_2 , causes them both to respond.

CHAPTER XL.

EDISON'S QUADRUPLIX TELEGRAPH.

THE quadruplex system of telegraphy, by means of which four communications, two in each direction, may be simultaneously transmitted over a single wire, has, within a few years, found very extensive practical application upon the lines of the Western Union Telegraph Company, and is at the present time operated upon 160 lines, between almost all of the principal cities in the country.

The distinguishing principle of this system consists in combining at two terminal stations, two distinct and unlike methods of single transmission, in such a manner that they may be carried on independently upon the same wire, and at the same time, without interfering with each other. One of these methods of single transmission is known as the double current system, and the other is the single current or open circuit system. In the double current system the battery remains constantly in connection with the line at the sending stations, its polarity being completely reversed at the beginning and at the end of every signal, without breaking the circuit. The receiving relay is provided with a polarized or permanently magnetic armature, but has no adjusting spring, and its action depends solely upon the reversals of polarity upon the line, without reference to the strength of the current. In the single current system, on the other hand, the transmission is effected by increasing and decreasing the current, while the relay may have a neutral or soft iron armature, provided with a retracting spring. A better form, however, for long circuits, is that of the polarized relay, especially adapted to prevent interferences from the reversals sent into the line to operate the double current system. In this system, therefore, the action depends solely upon the strength

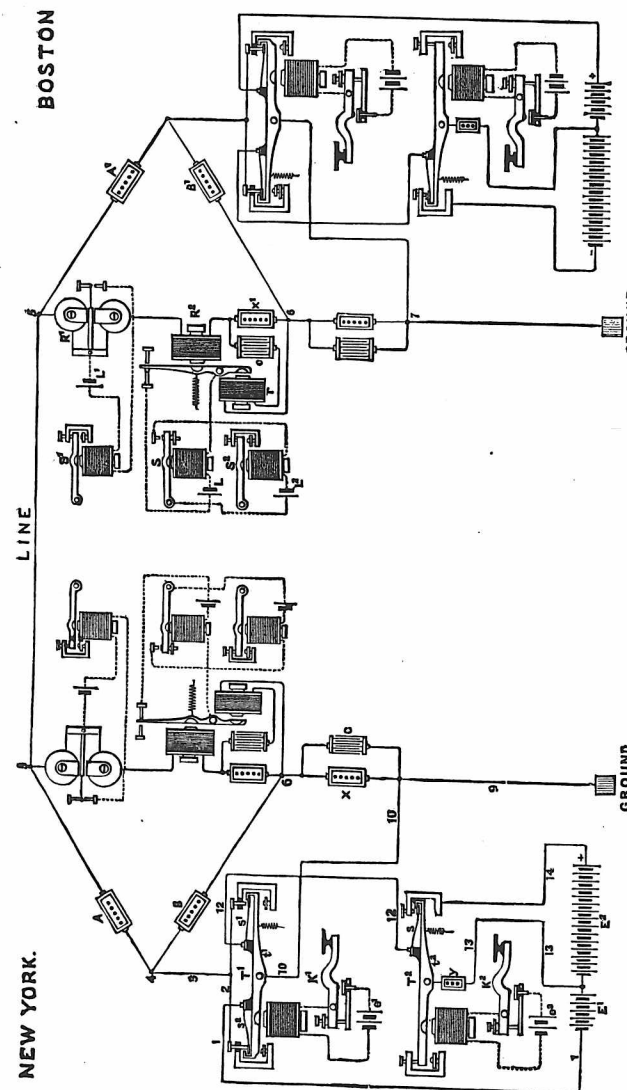
of the current, its polarity being altogether a matter of indifference

It will thus be apparent that by making use of these two distinct qualities of the current, viz., polarity and strength, combined with the duplex principle of simultaneous transmission in opposite directions, four sets of instruments may be operated at the same time, on the same wire. This method possesses, moreover, the important practical advantage that the action of each of the receiving relays is perfectly independent. Each receiving operator controls his own relay, and can adjust it to suit himself without interfering with the other.

Fig. 499 shows the quadruplex apparatus, as arranged upon the bridge plan, which was at first employed by the Western Union Telegraph Company in 1874, when the system was placed upon its lines.

T_1 is a double current transmitter or pole-changer, operated by an electro-magnet, local battery e_1 and finger key K_1 . The office of the transmitter T_1 is simply to interchange the poles of the main battery E_1 , with respect to the line and ground wires, whenever the key K_1 is depressed; or, in other words, to reverse the polarity of the current upon the line by reversing the poles of battery E_1 . By the use of properly arranged spring contacts, $s_1 s_2$, this is done without at any time interrupting the circuit. Thus the movements of the transmitter T_1 cannot alter the strength of the current sent out to line, but only its polarity or direction. The second transmitter, T_2 , is operated by a local circuit and key K_2 in the same manner. It is connected with the battery wire 12, of the transmitter T_1 , in such a way that when the key K_2 is depressed, the battery E_1 is enlarged by the addition of a second battery, E_2 , of two to three times the number of cells, by means of which it is enabled to send a current to the line of three or four times the original strength, but the polarity of the current with respect to the line of course still remains, as before, under control of the first transmitter T_1 .

At the other end of the line are the two receiving instruments R_1 and R_2 . R_1 is a polarized relay with a permanently mag-



netic armature, which is deflected in one direction by positive, and in the other by negative currents, without reference to their strength. This relay consequently responds solely to the movements of key K_1 , and operates the sounder S_1 by a local circuit from battery L_1 in the usual manner. Relay R_2 is placed in the same main circuit, and is provided with a neutral or soft iron armature. It responds with equal readiness to currents of either polarity, provided they are strong enough to induce sufficient magnetism in its cores to overcome the tension of the opposing armature spring. The latter, however, is so adjusted that its retractile force exceeds the magnetic attraction induced by the current of the battery E_1 , but is easily overpowered by that of the current from E_1 and E_2 combined, which is three or four times as great. Therefore, the relay R_2 responds only to the movements of key K_2 and transmitter T_2 .

The same difficulty which troubled former inventors arises again in this connection. When the polarity of the current upon the line is reversed during the time in which the armature of R_2 is attracted to its poles, the armature will fall off for an instant, owing to the cessation of all attractive force at the instant when the change of polarity is actually taking place, and this would confuse the signals by false breaks if the sounder were connected in the ordinary way. By the arrangement shown in the figure, the armature of the relay R_2 makes contact on its back stop, and a second local battery L_2 operates the receiving sounder S_2 . Thus it will be understood that when relay R_2 attracts its armature, the local circuit of sounder S_2 will be closed by the back contact of local relay S ; but if the armature of R_2 falls off, it must reach its back contact, and remain there long enough to complete the circuit through the local relay S and operate it before the sounder S_2 will be affected. But the interval of no magnetism in the relay R_2 , at the change of polarity, is too brief to permit its armature to remain on its back contact long enough to affect the local relay S , and through the agency of this ingenious device the signals from K_2 are properly responded to by the movements of sounder S_2 .

By placing the two receiving instruments R_1 and R_2 in the bridge wire of a Wheatstone balance, and duplicating the entire apparatus at each end of the line, the currents transmitted from either station do not affect the receiving instruments at that station. Thus in fig. 144 the keys K_1 and K_2 are supposed to be at New York, and their movements are responded to only by the receiving relays R_1 and R_2 at Boston. The duplicate parts which are not lettered operate in precisely the same manner, but in the opposite direction with respect to the line.

In applying this system of quadruplex transmission upon lines of considerable length, it was found that the interval of no magnetism in the receiving relay R_2 (which, as before stated, takes place at every reversal in the polarity of the line current) was greatly lengthened by the action of the static discharge from the line, so that the employment of the local relay S was not sufficient to overcome the difficulties arising therefrom. A rheostat or resistance X_1 was therefore placed in the bridge wire with the receiving instruments R_1 and R_2 , and shunted with a condenser c of considerable capacity. Between the lower plate of the condenser and the junction of the bridge and earth wire an additional electro-magnet r was placed, acting upon the armature lever of the relay R_2 , and in the same sense. The effect of this arrangement is, that when the current of one polarity ceases, the condenser c immediately discharges through the magnet r , which acts upon the armature lever of relay R_2 , and retains it in position for a brief time before the current of the opposite polarity arrives, and thus serves to bridge over the interval of no magnetism between the currents of opposite polarity.

It will be seen that the combination of transmitted currents in this method differs materially from any of those used in previous inventions. They are as follows:

1. When the first key is closed and the second open, $+1$
2. When the second key is closed and the first open -3 or -4
3. When both keys are closed..... $+3$ or $+4$
4. When both keys are open..... -1

Here we discover another very important practical advantage in the system under consideration, which is due to the fact that the difference or working margin between the strengths of current required to produce signals upon the polarized relay and upon the neutral relay, respectively, may be increased to any extent which circumstances render desirable. Within certain limits, the greater this difference the better the practical results, for the reason that the range of adjustment of the neutral relay increases directly in proportion to the margin. The ratio of the respective currents has been gradually increased from 1 to 2 to as high as 1 to 4, with a corresponding improvement in the practical operation of the apparatus.

From what has been said, therefore, it will be seen that before it became possible to produce a quadruplex apparatus capable of being worked at a commercial rate of speed upon long lines, it was essential that its component parts should have arrived at a certain stage of development. When, in the early part of 1872, simultaneous transmission in opposite directions was for the first time rendered practicable upon long lines by the combination therewith of the condenser, the first step was accomplished. It now only remained to invent an equally successful method of simultaneous transmission in the same direction, which, as we have seen, was done in 1874. The application of one or more of the existing duplex combinations to the new invention, to form a quadruplex apparatus, soon followed as a matter of course.

The following method of simultaneous transmission in the same direction was invented in December, 1875.

Fig. 500 is a diagram of the apparatus as arranged for quadruplex transmission. The lever t_1 , with its appendages, constitutes the first or single-point transmitter, which is the same as that of the Stearns duplex, being operated by an electro-magnet T_1 , local battery t and key K_1 . The second or double-point transmitter consists of a quadrangular plate of hard rubber, E , mounted upon an axis, and capable of being oscillated by the arm e , which is rigidly attached to it. By means of a spring e_1 , the

arm e presses upon a roller fixed upon one end of the lever d , which forces the other end of the lever against the stop d_1 . The lever d carries the armature of the electro-magnet T_2 , which, like the single point transmitter, is operated by a local battery and key K_2 . The oscillating plate E has four insulated contact points f, g, f_1, g_1 , upon its respective angles. The contact levers F and G are mounted on axes at each end of the plate E , and

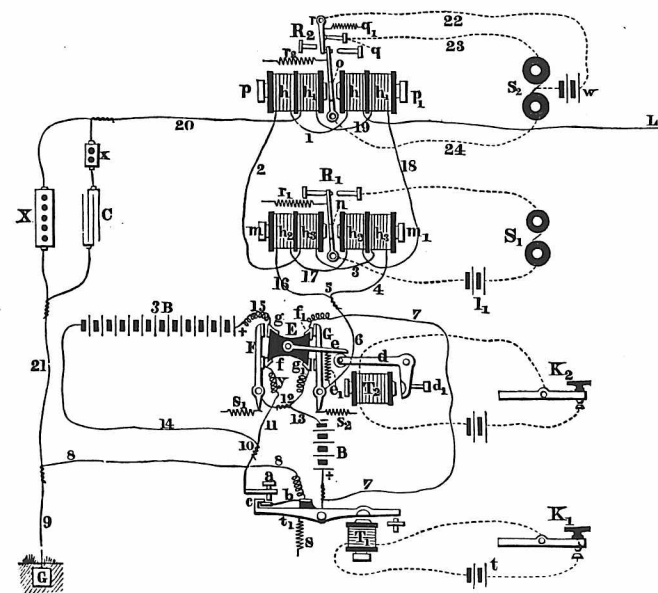
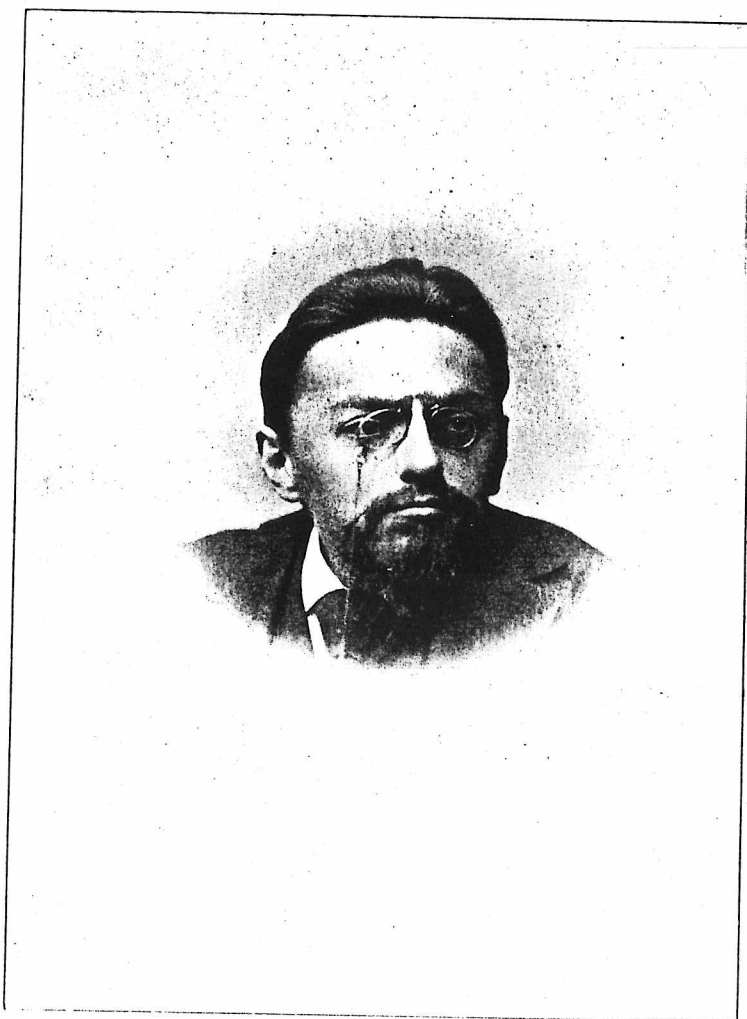


Fig. 500.

are pressed against it by springs s_1, s_2 . When the transmitter is in a position of rest, as shown in the figure, F is in contact with f and G with f_1 , and the parts are kept in this position by the action of the spring e_1 . When key K_2 is depressed, the arm e is raised by the action of the electro-magnet T_2 upon the bent lever d ; this turns the plate E upon its axis, and brings F into contact with g and G with g_1 .



Charles Proteus Steinmetz.

THE
TRANSACTIONS
OF THE
AMERICAN INSTITUTE
OF
ELECTRICAL ENGINEERS.



TK1,
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v.18
1901

VOL. XVIII.

PUBLISHED BY

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS,
95 LIBERTY STREET,
NEW YORK CITY, U. S. A.

1902.



14 504 684
near 611 in

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Total 11.

THE PRESIDENT:—The first paper of this evening is by Prof. W. Elwell Goldsborough on "Air-Gap and Core Distribution." Owing to the inability of Prof. Goldsborough to be here, Dr. Sheldon has kindly consented to read an abstract of the paper.

[See page 680, vol. xvii, for paper and discussion.]

The next paper is by Mr. William B. Vansize, "A New Page-Printing Telegraph."

A paper presented at the 150th Meeting of the American Institute of Electrical Engineers, New York, January 25th, 1901. President Hering in the chair.

A NEW PAGE-PRINTING TELEGRAPH.

BY WILLIAM B. VANSIZE.

The problem of automatically recording telegraph messages in Roman type is one that has fascinated inventors almost from the days of Morse. Royal E. House invented a type printing telegraph, which was in successful operation in this country in competition with the Morse and Bain systems prior to 1857. Many years ago the stock-ticker was perfected, and the Hughes, a tape printing telegraph, and several modifications of it have been employed for a long time with success by various telegraph administrations, chiefly on the Continent of Europe. But it is only within the last year or two, almost at the close of the 19th century, that the problem of constructing a long-distance, high-speed, page-printing telegraph has been solved. A printing telegraph of this kind has recently come to my attention.

It has received the commendation of practical men in the telegraph service, and is believed to be of such simplicity and merit as to win for itself and maintain a position among the apparatus and instruments in constant use on commercial telegraph lines. The arrangement referred to has been devised and constructed by and under the direction of Donald Murray, an Australian journalist, without prior practical experience in telegraph work.

A RETROSPECT.

Looking back over the last thirty years, a substantial part of which time has been spent in the service of the large telegraph corporations, I can recall but comparatively few arrangements of apparatus which have passed the experimental stage and gone into commercial use. In 1869 there was the well known Morse

key and spaced alphabet, with the relay and sounder, and in some few instances the embossing register at way stations. In 1872 or 1873, circuits were equipped with balanced receiving apparatus and continuity preserving transmitters for duplex transmission. A little later, reversals of current were used for one set of signals and variations in current strength for another set of signals, affording two transmissions in the same direction. By duplexing this last named arrangement the quadruplex was brought to a more or less satisfactory condition through the efforts of Edison, Jones, Nicholson, Prescott, Gerrit Smith and others. About 1875 there was introduced on the lines of the Atlantic and Pacific Telegraph Company an automatic system of transmission improved by Little and Edison, employing a perforated paper strip at the transmitting station, and a chemically-prepared paper strip to record the Morse characters at the receiving station. Some years later the Wheatstone system was first employed by the Western Union Telegraph Company. Later Mr. Delany's arrangement for distributing a single main line between a number of sending and receiving operators at separated stations was employed on a special line between Boston and Providence. Numerous systems of printing telegraph, recording upon a strip of paper and upon a page have been patented and exploited by corporations organized for that purpose. The Phelps motor printer, in this country, and the Hughes printing telegraph upon the Continent of Europe, both recording upon a strip, have had more or less extensive employment.

It is undoubtedly objectionable to use a perforated strip for transmitting purposes; but when to this is added a received record to be translated, there exist objections which only other merits, as in the case of the Wheatstone apparatus, partially compensate. At the other extreme is the simple Morse requiring no added time interval for translation at either end of the circuit; the operation of transmitting and recording being substantially co-extensive with the time in transit.

RECENT DEVELOPMENTS.

The later improvements in printing telegraphs have been directed to finding a substitute for the direct manual operation of the key-board and the employment of automatic transmission, like that of the Wheatstone system, by the use of perforated tape. The work of the operators in transmitting messages is

thus first stored in the perforated tape, produced at any convenient speed, and the automatic transmission may take place at a high and uniform rate, the line and receiving instruments being worked to their full capacity. Another means for overcoming the delay due to direct manual transmission is to divide up the use of the line among several operators, a locking device holding the line for an interval at the service of each in turn. In this case while the speed of the operator may be slow, the total use of the line and instruments is greater than one operator could achieve, working at his highest rate. There are two arrangements of apparatus now receiving attention employing the transmitting tape; that of Charles L. Buckingham, and that of Donald Murray, the latter here under consideration. The French system of Emile Baudot and the American system of Professor Rowland employ an arrangement for dividing the use of the line among several operators.

What telegraph officials really need is the simplicity of the Morse system combined with increased speed of transmission and economy of time between the transmitting customer and his addressed correspondent. Up to the present time nothing has surpassed the Morse for this purpose. We may economize time on the wire by the Wheatstone, by the chemical automatic system referred to, or by the use of Delany's multiplex system; we can provide for a special class of telegraph business by adopting some of the high speed transmitting systems like those contemplated by Professor Crehore, or by Delany's modification of the chemical automatic. For these high speed systems requiring preparation for transmission at one end and translation for delivery at the other end, a demand must be created by the requirements of a class of business to be transmitted and delivered faster than the mail, and somewhat slower than the transit time of the Morse system.

In the recent development of Morse there is an analogy between the contest between armor and armor-piercing projectiles on the one hand and the transmitter and receiver of the Morse code on the other. In the case of armored vessels an increase in the thickness or resistance of the armor has been answered by increased capacity for penetration by the projectile, and vice versa. In the early days the embossing or recording register could easily record the most rapid Morse sender. When receiving by sound it is an effort to keep up with the

speed of a rapid sender, where the receiver uses pen to record in script. When the typewriter is substituted for the pen, the receiver can more than keep pace with the sender; if we introduce automatic Morse transmission we surpass the power of the human ear to receive and translate to the typewriter. If we transmit mechanically and record mechanically by means of a typewriter we shall have eliminated these human agencies with their limitations, and that is what Mr. Murray has done in a very complete and satisfactory manner.

Before further considering Murray's arrangement I want to assign due credit to my friend Chas. L. Buckingham, who has a marvelously ingenious system in commercial use on the lines of the Western Union Telegraph Company. The received record is made in print on the ordinary telegraph blank; the transmission is by means of a perforated paper strip. It has a maximum capacity of about 100 words a minute on a circuit between New York and Chicago. The circuit can be duplexed to double the stated capacity. Its use, I believe, is successful, and commercially so.

MURRAY'S SYSTEM—TRANSMITTING ARRANGEMENT.

Mr. Murray employs a special alphabet, perforating the transmitting tape with a key-board perforator, having a separate movable lever for each character; each character occupies an unvarying linear space on the tape, and consists of five perforated and unperforated subdivisions of such space. The difference in the number and succession of these subdivisions or perforations imparts the designating characteristics. There are no spaces between successive letters or characters. Either makes and breaks, or reversals can be used in transmitting. It is to this fundamental fact—all letters of the same length—that the success of the system is due. Each letter occupies half an inch on the transmitting tape, and a similar length on the receiving tape. The result is that a comparatively simple transmitting tape perforator worked by an ordinary typewriter key-board is rendered possible; there is no necessity for employing a complicated differential paper feed mechanism to provide for letters of varying length. In connection with the ordinary typewriter key-board there is a group of ten punches, one punching magnet, and one spacing magnet, controlling a motor-driven escapement.

THE RECEIVING APPARATUS.

At the receiving station there is an electro-magnetic perforating device which accurately reproduces the transmitting tape by producing corresponding perforations and spaces. This received perforated tape passes from the receiving perforator into the typewriter operating device. This typewriter operating device consists of five longitudinally reciprocating bars or "combs," 39, Fig. 1, presenting five pointed terminals, 40, to a perforated plate or die, 38. The perforated tape passes between the surface of the perforated plate and the pointed terminals of the bars. The pointed terminals of these bars register respectively with the five holes in the die. The tape is moved along between the die and the pointed ends of the bars step by step, the length of a letter or character at each step, say one-half inch. When perforations in the tape coincide with the pointed ends of the bars and corresponding perforations in the plate and die, and the plate is moved toward the pointed ends of the bars, the bars are or may be separated into two groups; one group is moved longitudinally, corresponding with the unperforated subdivisions of the tape, the other group project through the perforations in the tape and in the die, and are unmoved. Lying over the five bars or "combs" at right angles thereto, are a series of thin metal strips, 41; each strip is mechanically connected with its individual key lever on the typewriter. The upper surface of the five bars first described are notched arbitrarily. These notches are caused to be aligned below any one of the strips under the control of the perforated tape and die; when any one of the strips drops into a groove a motor-driven cam engages it and produces a movement of the typewriter lever. The movement of the die and paper tape and of the typewriter key-lever is produced by motor-driven cams. It will be seen that this mechanism will operate not only a typewriter, but any keyboard machine such as a typesetting machine or linotype. The perforated receiving tape is therefore available for setting type automatically.

THE GENERAL DIAGRAM.

In the general diagram (Fig. 1) shown, there is the apparatus at the transmitting station connected by a single main line 9 with the apparatus at the receiving station. I have placed a double marginal line around the apparatus at the transmitting station to distinguish it. The vibrating reed 1 is in a local cir-

cuit with an electromagnetic motor 2. The reed makes and breaks its own circuit, and is substantially like the well known LaCour

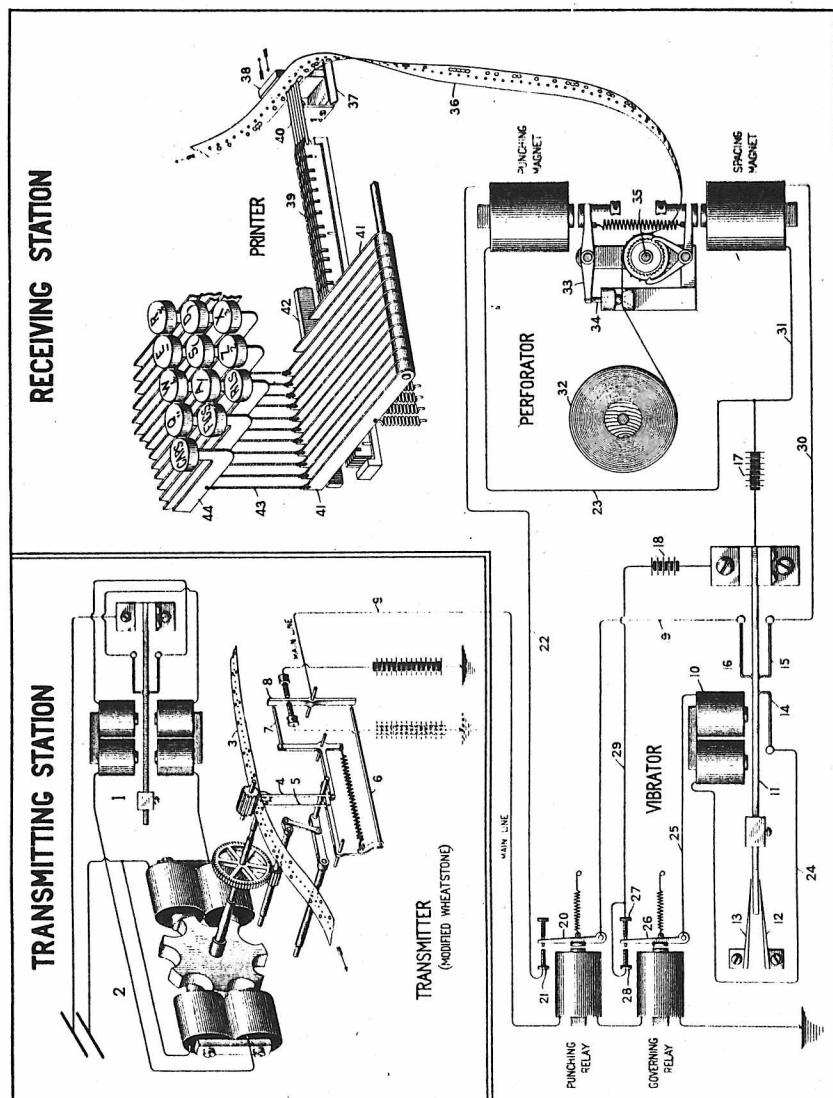


FIG. 1.

phonic wheel device. The "prickers" 4 and 5, familiar features in the Wheatstone transmitter are located as usual in line with the advancing lines of perforations in the transmitting tape 3;

6 and 7 are reciprocating rods engaging respectively with opposite terminals of the centrally pivoted pole changing switch arm 8. The parts shown are all essential parts of the well known Wheatstone transmitter, which is here used practically without alteration, except that the prickers 4 and 5 are arranged to move or reciprocate together instead of alternately, thereby enabling any described multiple of a single impulse to be transmitted. The ordinary arrangement of the Wheatstone transmitter can only transmit unit signals or odd number multiples thereof; it is practically an alternating current generator. The Wheatstone signals have to be built up by omitting a positive or negative impulse, hence an ordinary Wheatstone transmitter can transmit a dot or a dash equal to three or five dots, but cannot transmit a dash equal to two or four dots. Mr. Murray, to avoid this difficulty, arranges the prickers to reciprocate together instead of alternately. There is thus obtainable, transmitted impulses or dashes equal to one, two, three, four, or five dots, with corresponding spaces.

In transmitting, the number of impulses thrown upon the main line is minimized by producing the impulses locally at the receiving station, and employing only sufficient main line impulses to determine the action of the perforator. At the receiving station there is, therefore, a main line relay to determine the action of the punching magnet, and a governing relay which operates to maintain unison between the main line impulses as they arrive and corresponding impulses in the local circuit. For the purpose of creating these local uniform impulses there is a vibrating reed, 11, operated by an electro-magnet, 10. The circuit of this magnet extends from the local battery 18 through the reed 11, contact point 14, wire 24, magnet 10, wire 25, armature 26 of the governing relay, thence by way of the points 27 or 28, and wire 29, to the battery. The precise operation of the governing relay I will describe presently. The receiving perforator is composed of a punching magnet and a spacing magnet; the punching magnet operates a spring-retracted pivoted armature bar, 33, mechanically connected with the punch 34, reciprocating through a guide block and engaging the tape 32 upon the surface of a suitable die, over which the tape passes. The tape is fed along by a star wheel located on a motor-driven shaft, 35, and upon this shaft is an anchor escapement under control of the spacing magnet. The vibrating

reed 11 alternately makes and breaks the local circuit of the spacing magnet; this circuit extends from battery 17 to the reed 11, contact spring 15, wire 30, through the magnet and wire 31 to the battery. The punching magnet is in a local circuit with a break point operated by the vibrating reed 11 and controlled by break points of the punching relay, so that while the reed is continually generating local circuit impulses, these impulses are effective to operate the punching magnet at such times only as the punching relay is closed upon its front contact. This local circuit passes from the battery 17 through reed 11 to contact point 16, thence by wire 19, armature bar 20, contact 21, wire 22, through the punching magnet, and wire 23 to the battery. It will thus be seen that the reed 11 is continually making and breaking two circuits alternately; first, that of the spacing magnet, which is a continuous operation; and second, that of the punching magnet, which is an intermittent operation, rendered so by the action of the punching relay. This punching relay and also the governing relay may be either neutral relays responsive to makes and breaks, or they may be polarized relays responsive to reversals of current. As the reed 11 vibrates, the electric impulses in the spacing magnet circuit permit a steady progressive movement of the tape 36. Upon the arrival of an impulse of current from the transmitting station, the contact points 20 and 21 of the punching relay are held closed for one, two, three, four or five times the time interval of one dot length, and while this relay circuit breaker is closed, the punch 34 operates to perforate the tape as many times successively as permitted by the time length or duration of the transmitted impulse upon the main line. Mr. Murray has thus avoided the necessity of transmitting over the main line all impulses necessary to produce spacing, and all but a fractional part of the impulses necessary to produce the perforations. It is of vital importance, however, to preserve unison between the arriving transmitted impulses in the main line and the local punching and spacing impulses at the receiving station. This is done in the following manner:

HOW UNISON IS MAINTAINED.

The governing relay operates a circuit breaker, 26, moving between two fixed contacts, 27 and 28, electrically connected to the same circuit terminal, so that the moving contact in going

from one to the other operates to open the circuit during its time of transit only. I have referred to this briefly as "armature transit time." This break in the local vibrator circuit takes place at the beginning and end of each main line signal, and as the main line signals arrive at a uniform rate and are of unit or multiple unit duration, the governing relay operates its break-point at uniform unit intervals or multiples of these intervals. In the same circuit in which this break-point operates, there is also the break-point 14 of the motor magnet 10, which works on the familiar buzzer principle. There are thus two break-points in the same circuit. If they open and close together, then full vibratory impulses flow through the motor magnet. If, on the other hand, the rate of vibration of the reed tends to accelerate, or the rate of the arriving current signals tends to lag, then the two breaks occur more or less alternately and consequently less current gets through—the impulses are clipped—and the rate of vibration of the reed is reduced. In practice, the receiving vibrator is set to go one or two per cent. faster than the rate of the arriving signals, and then the governing action of the two interfering break-points in the same circuit results in the establishment of a steady dynamic balance between the accelerating tendency of the reed and the retarding tendency of the arriving main line signals. By this arrangement the necessity for sending correcting impulses over the main line to secure synchronism is avoided, the correcting impulses being obtained locally with the co-operation of the main line signals themselves.

It is to be understood that movable weights are present upon each reed, that of the transmitting station and that of the receiving station, and by varying the position of the weight upon the reed, the rate of vibration and the rate of transmission may be changed. At the receiving station there is provided means whereby the rate of vibration of the reed may be varied in harmony with variations in current in its motor magnet circuit. Under normal conditions with a motor magnet and circuit operated by break points carried by the reed, an increase of current, resulting in increased magnetic effort, will decrease the rate of vibration, and, conversely, a decrease of current resulting in decreased magnetic effort will accelerate the rate of vibration. This is believed to be due to eddy-currents generated by the magnetic field of force and the movement of the reed in such field. The action described while it has a damping effect, is of

no practical use as a means of regulation for the work to which the reed is here put, because of its exceedingly limited range. It is necessary in maintaining unison to have a considerable range of variation in the speed of this reed, such variation in speed to be attained in response to variation in the length of current impulses of uniform strength.

CONSTRAINED VIBRATION OF THE REED.

To secure this result there is placed at or near the free end and upon the opposite sides of the reed, resilient stops, shown at 12 and 13. These springs receive the reed on each side with a cushioning effect and impart an initial return movement. In explanation of this result it is to be recalled that the rate of vibration of a reed varies with its length, mass, and the distribution of such mass; increase of current in the motor magnet circuit increases the amplitude of vibration without varying the speed beyond the slight electro-magnetic damping effect already described. The energy imparted to the reed by the motor magnet is dissipated by the air resistance and molecular friction in the reed; an increase in the propelling energy brings a corresponding increase in the dissipation noted. Therefore, while the amplitude of vibration is widened, the speed is not increased. If fixed limiting stops be provided, to limit the amplitude of vibration, the energy of the reed cannot then be dissipated in the manner first described to the same extent, and there results an increase in the rate of vibration, while a portion of the energy imparted to the reed is dissipated in heat generated at the point of impact. To avoid this loss and further increase the rate of vibration, the energy which would otherwise be lost at a rigid contact is stored in the resilient devices, 12 and 13, already referred to, to cushion the impact of the reed, and impart an initial return movement. By this expedient, the movement of the reed is rendered smooth and uniform; it is freed from the interference due to the impact with a rigid stop, which acts to jar and disturb the normal rate of vibration, and its rate may be varied by varying the current impulses.

In further explanation of this device we may recall the fact that, within the limits of elasticity, a helical spring varies in length in arithmetical ratio with the force extending it; that is to say, if a helical spring extends one inch with a weight of one pound, it will extend two inches with the weight of two pounds,

and so on. Within restricted limits the same rule holds good with simple flat springs of uniform thickness, like those commonly employed for electrical contact purposes. It has been found by experiment that springs of this kind, whether arranged for tension or for compression, do not vary the rate of vibration of the motor-driven reed to any appreciable extent in response to variations of current in the motor magnet circuit; but if resilient stops are constructed and arranged, like 12 and 13, to rapidly compound their resistance to the impact of the reed, they are practically operative for the purpose of varying the rate of vibration in response to variation in current.

CURVES OF VIBRATION OF REED

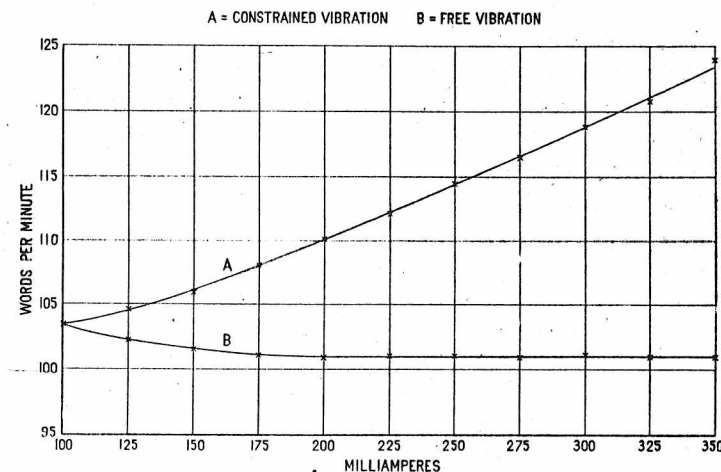


Fig. 2.

CURVES OF VIBRATION OF REED.

I have here a diagram [Fig. 2] showing the action of a reed when free to vibrate without limiting stops, as compared with the action of the same reed operating under the constraint imparted by the tapering springs, called resilient limiting stops. The figures were obtained by varying the amount of current flowing through the reed magnet coils and then measuring the amount of tape fed through the perforator under control of the reed. The tape is fed forward one step for each vibration of the reed, and its extent therefore gives an exact record of the rate of vibration per minute. The receiving vibrator and other

instruments were set to transmit and record at the rate of 112 words per minute, and the current in the reed magnet was then varied with the following result:

Current in Milliamperes.	Tape fed per minute.	
	ft.	in.
350	24	0
325	23	$4\frac{1}{4}$
300	23	0
275	22	$0\frac{3}{4}$
250	22	$1\frac{3}{4}$
225	21	$8\frac{1}{2}$
200	21	4
175	20	11
150	20	6
125	20	3
100	20	$\frac{1}{2}$

The action of the resilient limiting stops began at 100 milliamperes. The vibration with this amount of current was very slight. About 230 milliamperes were used for the 112 word rate.

The following table shows the effect of removing the resilient limiting stops, all other conditions being as before.

Current in Milliamperes.	Tape fed per minute.	
	ft.	in.
350	19	$6\frac{1}{2}$
325	19	$6\frac{1}{2}$
300	19	7
275	19	$6\frac{1}{2}$
250	19	$6\frac{3}{4}$
225	19	$6\frac{1}{2}$
200	19	6
175	19	7
150	19	8
125	19	$9\frac{1}{2}$
100	20	$\frac{1}{2}$

The reed did not vibrate reliably under 100 milliamperes, and even with that current it was feeble. The vibration did not become fairly strong until 125 milliamperes was reached. The figures and the curves indicate that the speed increases with decrease of current below 150 milliamperes. This was possibly due to the electro-magnetic damping effect of the iron armature vibrating in the magnetic field. Actual trial has shown that this effect is too feeble and unstable to be used for governing the rate of the reed by possible variation in the current. A more posi-

tive and reliable result was required, and it was supplied by the resilient limiting stops. It will also be seen by the diagram that above 150 milliamperes the rate of vibration of the reed is uniform irrespective of the amount of current when the reed is not constrained by the resilient limiting stops. This is indicated in the straight horizontal portion of the curve B. Curve A shows the effect of the resilient limiting stops in causing an almost uniform acceleration of the speed of the reed in accordance with the increase of current. With respect to the curve A the variation in words per minute between extreme points is from 103 words with 100 milliamperes to 123 words with 350 milliamperes, and with respect to the curve B the variation in words per minute is from 103 words at 100 milliamperes to 101 words at 350 milliamperes, a perceptible decrease in the word rate, with an increase of $3\frac{1}{2}$ times in the strength of current.

FORMS OF RESILIENT STOPS

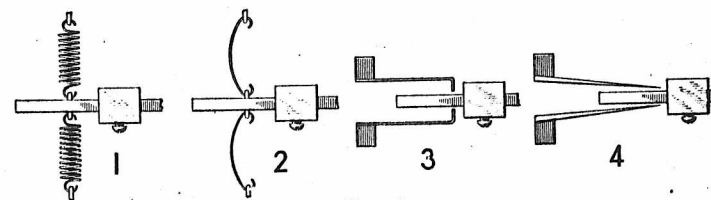


FIG. 3.

The forms of limiting stops experimented with and heretofore referred to are shown upon the diagram "Forms of resilient stops" [Fig. 3]. Nos. 1 and 3 are practically ineffective for the purpose intended; No. 2 is susceptible of some beneficial use, while No. 4 is a practically successful arrangement, and the one to be preferred.

THE UNISON DIAGRAM.

I have here a "unison diagram" [Fig. 4] to illustrate the relative position of the current impulses in securing unison. There is shown a section of receiving-tape in which appears the word "Paris," the division between the letters being marked with a dotted line. Below the line of the tape is shown the corresponding conditions of current in the local and main line circuits; when in unison, and again when out of unison. In line 1 there is shown the current impulses in the punching magnet

circuit effective to produce the perforations shown on the section of tape; line 2 shows the current impulses in the local spacing current; at line 3 is shown the main line impulses due to the operation of the automatic transmitter effective to produce the perforation in the tape represented; at 4 is shown the operation of the armature of the governing relay, the unshaded divisions representing the "armature transit time," and the relative position of the armature transit with respect to the impulses in the main and local circuits; at line 5 is shown the impulses in the motor magnet circuit which operate to drive the reed; these impulses are shown as in unison with the main line and local circuit impulses. In line 6 is shown the same motor magnet circuit impulses out of step, or out of unison. The continuous operation

UNISON DIAGRAM

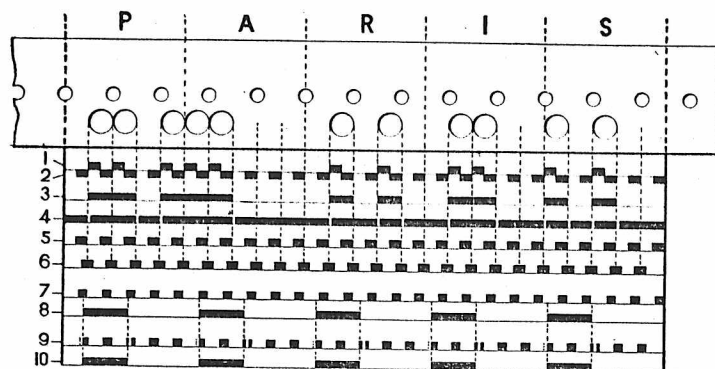


FIG. 4.

of the unison device is best illustrated in the actual record taken upon a chemically prepared paper tape with a pair of iron pens, one in the local circuit and one in the main circuit; the pens were arranged side by side; line 7 shows the record of impulses in the motor magnet circuit; line 8 shows the main line impulses, the action of the armature of the governing relay having been suppressed. In lines 9 and 10 the same means are employed to render graphic the impulses in the two circuits, and the operation of the transit of the armature bar 26 of the governing relay is also apparent in clipping the local circuit impulses, and thus curbing their motive power effect on the reed. There

is thus established a continuous "dynamic balance" between the tendency of the reed to accelerate its speed and the tendency of the main line signals to retard its speed. The shape of the punch for perforating the receiving tape is quite important. A large number of forms were tried. The diagram "Forms of Punch" [Fig. 5], shows some of the leading shapes. No. 5 is much the best.

TELEGRAPHIC ALPHABETS.

In considering the merits of this arrangement of apparatus and in accounting for the want of commercial success of so many other arrangements, it may be said that printing telegraphs have not been generally employed for the following reasons, among others:

1. Delicacy and complexity.
2. Slowness of operation.
3. Limitation in the capacity of the operator.
4. The use of a tape for the received record.

FORMS OF PUNCH

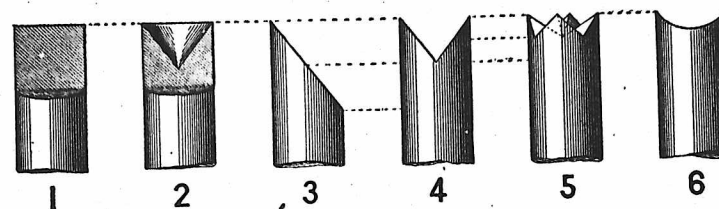


FIG. 5.

Recently some arrangements of apparatus have been devised which overcome these difficulties by two radically different methods; *i. e.*, automatic transmission and multiple transmission. The first uses the Wheatstone transmitter and perforated tape; the second employs direct manual transmission distributing the time for using the line between a number of operators. The slowness of operation has been due not only to the limitations of the operator, but also to the character and succession of the line impulses employed. In long distance working and with the growing use of underground and aerial cables, this is of extreme importance. The reliable material for high speed signaling over long distances in printing telegraphy consists prac-

tically of five or six variations in the time interval; two variations in direction, and one variation in strength, *i. e.*, makes and breaks. Two very desirable conditions are that letters shall be of uniform length, and that either makes and breaks or reversals shall be used, but not combinations of the two. The Morse alphabet is ideal except for the great variation in the length of the characters.

The importance of an alphabet having letters of equal length has been generally acknowledged, and many designers have adopted the only practical arrangement, namely, thirty-two possible combinations of five positive and five negative elements taken five at a time. Such an alphabet was first suggested by Gauss and Weber of Göttingen in 1833. It was revived in 1874, when Baudot and others employed it for their multiplex printing telegraph systems. Baudot's arrangement, which may be taken as typical of this class of equal letter alphabets, is shown in the diagram called "Table of Alphabets" [Fig. 6]. It has the disadvantage of using makes and breaks as well as reversals, necessitated by the use of equal units of current to form the various combinations for the letters.

THE MURRAY ALPHABET.

Murray by using multiple units of current and space (that is by using several different time intervals instead of one only) avoids this disadvantage and has not found it necessary to use reversals, five different time intervals combined with makes and breaks giving all the combinations required. He has preserved the ideal simplicity of the Morse alphabet with the added advantage of securing letters of the same length. The Murray alphabet appears in the table; it will be seen that the uniform time for each letter is divided into five equal units or subdivisions, one or more of these five subdivisions being a current impulse, so that we get current impulses or spaces of one, two, three, four or five units duration. Thirty-two possible combinations are obtained in this manner, and by using two of these letter signals as prefixes to the others, capitals, figures, and lower case letters, about eighty-seven characters, may be transmitted. Makes and breaks or reversals may be used, therefore, adapting the system for use in quadruplex transmission; a use not practicable with an alphabet employing both makes and breaks and reversals. The alphabet is however only available for machine telegraphy,

as it is practically impossible to observe five different time intervals with sufficient accuracy in manual transmission. No space is required between letters in the Murray alphabet, whereas in the Morse a three unit space follows each letter. This is shown in the "Table of Alphabets." It will be seen upon examination that the maximum number of impulses required is

TABLE OF ALPHABETS

	LET-TERS	FRE-QUENCY	"MURRAY" SIGNALS	TAPE	"BAUDOT" ALPHABET	"INTERNATIONAL" MORSE	"AMERICAN" MORSE
1	e	14,000	—	0...0	—	—	—
2	t	10,000	—	...0	—	—	—
3	a	9,000	—	00...0	—	—	—
4	i	9,000	—	00...0	—	—	—
5	n	8,000	—	00...0	—	—	—
6	o	8,000	—	00...0	—	—	—
7	s	8,000	—	0...0	—	—	—
8	r	7,000	—	0...0	—	—	—
9	h	6,000	—	0...0	—	—	—
10	d	5,000	—	0...0	—	—	—
11	l	5,000	—	0...0	—	—	—
12	u	4,500	—	000...0	—	—	—
13	c	4,000	—	000...0	—	—	—
14	m	3,000	—	000...0	—	—	—
15	f	3,000	—	000...0	—	—	—
16	w	2,500	—	000...0	—	—	—
17	y	2,500	—	0...0	—	—	—
18	p	2,400	—	0...0	—	—	—
19	b	2,000	—	0...0	—	—	—
20	g	2,000	—	0...0	—	—	—
21	v	1,500	—	0000	—	—	—
22	k	800	—	0000	—	—	—
23	q	600	—	0000	—	—	—
24	j	500	—	0000	—	—	—
25	x	500	—	0000	—	—	—
26	z	300	—	0000	—	—	—
27	,	4,500	—	0...0	—	—	—
28	.	3,000	—	0...0	—	—	—
29	Space Key		—	0...0	—	—	—
30	Capital Key		—	0...0	—	—	—
31	Figure Key		—	0...0	—	—	—
32	Release Key		—	0...0	—	—	—

FIG. 6.

three for the letter y, and the average number reckoned according to the frequency of the letters is 1.25 impulses as against 2.59 for International Morse. As compared with this 1.25 impulses per letter, a system employing the Baudot alphabet has to transmit not less than five, and this does not take into account

the necessary correcting impulses to secure or maintain synchronism. Murray has the shortest alphabet possible to be constructed from reliable signaling material and by combining it with machine transmission the entire time of the line is used in the most advantageous manner possible.

COMPARISON OF ALPHABETS.

Referring to Fig. 7, "Comparison of Alphabets," it will be seen that the Murray word is shorter than the Morse in the ratio of 30 to 51, or 41.18 per cent. This theoretical diagram is borne out by a comparison made with an actual word such as PARIS. This comparison is made on lines 13 and 14. It will be observed that in this case the Murray alphabet is shorter than the Morse

COMPARISON OF ALPHABETS

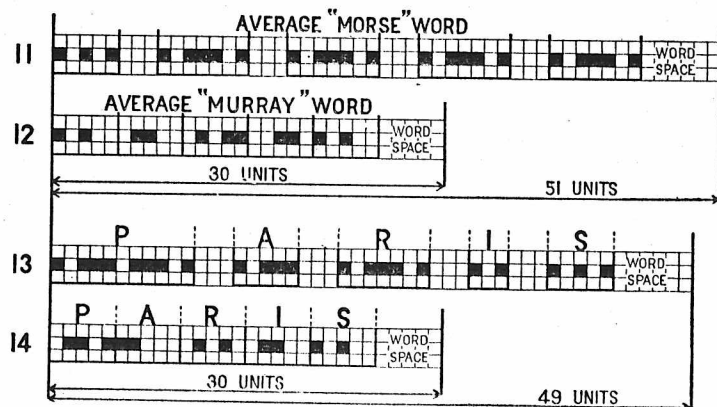


Fig. 7.

in the ratio of 30 to 49, or 38.78 per cent. Practically, the two alphabets are in the ratio of 3 to 5. Hence using the same number and length of current impulses in each case, a speed of 100 words a minute with the Murray alphabet would not be more than about 60 words a minute in Morse. The saving in the Murray alphabet lies chiefly in the fact that there is no space between the letters. Indeed, signals in adjoining letters not unfrequently coalesce, as will be seen in the case of the letters P and A in the word PARIS, where one current impulse is actually shared by the two letters, and five letters are transmitted by seven im-

pulses, whereas in the Morse representation of the same word no less than 14 impulses are required. Many combinations of letters like te, ta, ma, me, ou, are sent by one impulse, and the German name Latzke, consisting of six letters, requires only four current impulses for its transmission. This, however, is exceptional, the average being 1.25 impulses per letter. The Hughes printing telegraph employs only one impulse per letter, but it is extremely wasteful of the space between signals, so much so that, on the average, not more than three impulses per second are transmitted over a line which will easily convey thirty per second. The Murray alphabet, on the other hand, economizes spaces as well as signals to the utmost extent.

TESTS OF THE SYSTEM.

From time to time, as the system developed, careful tests were made of its capacity, both on loops of varying lengths and on circuits between cities. The speeds mentioned below were calculated on the basis of five letters to the word and a word-space equal to one letter. That is to say, the receiving tape fed through the perforator in one minute was measured to find the number of letters it contained, and this number was divided by six. In April and May, 1900, a series of tests were made between New York and Chicago. Working direct from Chicago to New York via Meadville without a repeater, a distance of 1050 miles by the route of the wire, the best speed attained was 77 words a minute. Working with a repeater at Meadville, much better results were achieved, 102 words a minute being easily attained. The wire used was copper, 208 lbs. and 4.5 ohms per mile. Duplex working was readily secured. Attempts were made to reach a speed of 114 words a minute. These were only partially successful, but the results gave promise of a speed of at least 120 words a minute in the future.

The most exhaustive tests of the system were made, from the 17th October to the 3d November, 1900, between Boston and New York. Two hundred ordinary commercial messages were taken without selection from the files in the operating room of the Postal Telegraph Company in New York. They consisted of 160 business telegrams (including 18 in cipher) and 40 domestic and social. They averaged 10.8 words in the paid portion of each message. Following the usual practice of counting single figures as words, they averaged about the usual rate of 30 words

per message; but counting figures as single letters, and counting all letters by measuring the transmitting tape and dividing by six, the average was about 26 words per message. These 200 messages were perforated in Wheatstone tape. A column press despatch from the *New York Herald*, containing 5988 letters and 1261 words, or an average of 4.75 letters per word, was also prepared in Wheatstone tape. This press despatch and the 200 commercial messages were transmitted from Boston to New York day after day at speeds varying from 60 to 96 words per minute. It was found that the apparatus worked with great accuracy, the whole 200 messages frequently coming through without error. At other times occasional errors occurred, owing to swinging wires and other familiar line troubles common to all telegraph systems. In addition to the 200 messages prepared beforehand in New York, a number of ordinary messages were perforated in Boston and transmitted to New York without difficulty, and almost without experience on the part of the Boston operators.

In regard to the number of messages transmitted per hour, in tests made when the apparatus was running at 61 words per minute, the 200 messages came through to New York in one hour 23 minutes. This is a speed of about 144 messages per hour, or more than three times the average rate of transmission by the Morse key, 40 messages per hour being regarded as a fair day's work for an average American operator. At the 96-word rate the messages came through at about 230 per hour. At the same rate the press despatch, with the last part repeated, making in all 1720 words, came through without an error in 16 minutes 42 seconds, or at the actual rate of about 103 words per minute, the words averaging only 4.75 letters each. A speed of 110 words per minute (115 actual words per minute) was tried, but at this rate not more than 200 or 300 consecutive words came through free from error. The inventor believes, however, that with increased skill and improved instruments, his system will ultimately reach a reliable speed of 120 words a minute. Working on a loop from New York to Albany and back, up one side of the Hudson River and down the other, speeds of 114 and even 118 standard words per minute have been successfully obtained. The length of the Postal Telegraph Company's lines from New York to Boston is about 290 miles, and the lines include from 20 to 30 miles of cable. Over this comparatively

short line the system did not require any readjustment for weather, which varied during the tests from clear and cold to dense fog and rain all the way between the two cities. Duplex working was perfect.

It will be seen from the foregoing tests that this system, working at the 60-word rate, has a capacity of 140 messages per hour. Cutting this down to 120 messages per hour to allow for corrections and delays, and working duplex, there is an output of 240 messages per hour, or 50 per cent. more than the Morse quadruplex can achieve. Working at the 96-word rate, the system has the capacity to transmit two and a half times as many telegrams as the quadruplex. No doubt these figures will be considerably reduced in commercial practice, but there is a wide margin for such reduction.

The tests have shown that, owing to the characteristic alphabet, distances of 1000 miles are not an obstacle, and the inventor is sanguine enough to believe that it will be possible, though not at present commercially practicable, to work between New York and San Francisco, a distance of 3000 miles, at a speed of at least 40 words a minute, or double the rate of manual transmission.

I may add that W. H. Baker, the Vice-President of the Postal Telegraph Cable Company, to whose foresight is due the benefits of securing Mr. Murray's improvements, thinks that the received tape may be employed to operate a Mergenthaler Linotype Machine, or other type setting machine. Others, including Mr. Murray, are of the same opinion, but so far no use has been made of this application of the invention, commercially.

NOTE.

The figures upon which the comparison of alphabets is based have been obtained by means of the following table, which shows the average number of signals per letter employed in the "International" Morse alphabet and in the "Murray" alphabet:—

1	2	3	4	5	6
Letters	Frequency	"Morse" Signals	Products (1)	"Murray" Signals	Products (2)
e	140	1	140	1	140
t	100	1	100	1	100
a	90	2	180	1	90
i	90	2	180	1	90
n	80	2	160	1	80
o	80	3	240	1	80
s	80	3	240	2	160
r	70	3	210	2	140
h	60	4	240	2	120
d	50	3	150	2	100
l	50	4	200	2	100
u	45	3	135	1	45
c	40	4	160	1	40
m	30	2	60	1	30
f	30	4	120	2	60
w	25	3	75	3	75
y	25	4	100	2	50
p	24	4	96	2	48
b	20	4	80	2	40
g	20	3	60	2	40
v	15	4	60	1	15
k	8	3	24	1	8
q	6	4	24	2	12
j	5	4	20	2	10
x	5	4	20	2	10
z	5	4	20	1	5
1193		3094		1688	
$\frac{3094}{1193} = 2.59$		$\frac{1688}{1193} = 1.41$			

This table is based on the average frequency of occurrence of letters of the alphabet as shown by a printer's "bill of type" as given in "Practical Printing," by Southward. This frequency is given in column 2. In column 3 is given the number of "International" Morse signals for each letter, and in column 4 is given the products obtained by multiplying columns 2 and 3 together. The sum of column 4 divided by the sum of column 2 gives the average number of signals per letter as 2.59. "American" Morse reckoned out in the same way gives an average of about 2.4, or about 8% less. But when the space allowance between signals, letters and words is reckoned in, this 8% advantage is reduced to somewhere about 5%. Column 5 and 6 give similar figures for the "Murray" alphabet, which proves to have an average of 1.41 signals per letter. This average is reduced in practice to about 1.25, owing to the fact that the current impulses in two adjoining letters frequently coalesce. Taking into consideration the frequency of letters, the International Morse alphabet contains on the

average 5 dots to 3 dashes. Hence as the average Morse letter contains 2.59 signals, the average Morse word of 5 letters contains approximately 6 dots, 4 dashes, and 5 fractions. This fraction is .59 of an average dot-dash. As there are on the average 5 dots to 3 dashes, and as 1 dash is equal to 3 dots, if we divide 14 by 8 we get the average dot-dash, which is in this way found to be equal to 1.75 dots. .59 of this is almost exactly 1 dot. The 5 fractions are, therefore, 5 dots. Hence the average International Morse word of 5 letters consists approximately of 6 dots, 4 dashes, and 5 dots (for the letter fractions), and the necessary spaces, namely, 1 dot-space between each letter signal, 8 dot-spaces between each letter, and 6 dot-spaces at the end of the word. The average word in the Murray alphabet consists of five letters, each letter containing 5 dot-spaces filled with various combinations of signals. The word space is of the same length as the letters, namely 5 dot-spaces. Having these figures, it is possible to make diagrammatic representations of an average word in the International Morse and in the Murray alphabet. This is done in the foregoing diagram headed Comparison of Alphabets. Line 11 gives an average International word, and line 12 gives an average Murray word.

DISCUSSION.

THE PRESIDENT:—This very interesting paper is now open for discussion. The improvements which may be expected in telegraphy in the new century will undoubtedly be in this direction, namely, increasing the speed, and at the same time receiving the messages in printed characters, either directly or by machine transcribing, as in this case. There are several ways in which this can be done, as stated in the paper, and it is a matter of considerable interest to observe which of these methods are going to be successful in practice.

There are a few things which, it seems to me, were not made quite clear in the paper, and which might be interesting to have Mr. Vansize describe to us more fully. One is the way in which the page printing is done from the perforated tape of the receiver. It would also be interesting to know whether the apparatus is already in commercial use, and if so, how long it has been in such use. There is another point that occurred to me while listening to the reading of the paper, and that is, whether at the receiving end, the perforated tape could be used for relaying a message, and also for duplicating; that is, for redistributing the received message by repeating it over a number of different lines from central stations.

MR. GEO. T. HANCHETT:—I should like to ask, too, what means are used to manipulate the carriage of the typewriter, that is, to shift it when a line is completed, and to move the sheet up one notch? I presume it is done by the tape, but the mechanical motion afforded by the tape is not of sufficiently powerful character, it seems to me, to move the carriage or the paper.

MR. VANSIZE:—In answer to the last question I will say that up to the present time it has been customary to let the supervising operator who is necessarily at hand, shift the paper, although I suppose it might be done by a characteristic perforation in the tape.

In reply to the inquiry of the President, I would say that the tape at the receiving station has not been adapted for repetition into another circuit. The received impulses differ in essential respects from the tape that is used for transmitting.

In regard to devices for actuating the typewriter itself, you will recall the fact that there is a separate instrumentality located below the typewriter in a frame. That instrumentality consists of a series of five combs, as we call them. Each comb is characteristically slotted. Lying across those combs at right angles are a number of thin metal bars in number corresponding to the number of independent keys on the typewriter. When a series of notches are in line below any one of those bars, one of those cross-bars which is connected to the typewriter lever will drop into it. The appropriate motive power is furnished by cams, and a description of the exact mechanical arrangement would be

quite intricate. It is present there, in the machine which we exhibit. In order to get the combs aligned to cause the manipulation of any one letter, we employ a perforated tape. You can imagine the tape perforated, and you can imagine the tape having one-half inch lineal extent assigned to each character, and there may be one, two, three, four or five perforations, or one perforation may occupy any relative position between the ends of that half-inch space. The tape is fed along in front of a die-plate one-half inch at each step, and when so fed along one or more of the holes in the perforated section will register with one or more of five perforations in the die-plate. When a hole in the paper is in position and registers with one of the holes in the die-plate, the pointed end of one of the combs (before referred to) is in position, and free to pass through the perforation in the hole in the die-plate, or two or more combs may be in position to pass through registering holes in the tape and die. There is a cam which imparts to the die-plate an advance movement. As it advances the end of one or more of those combs passes through the holes in the paper, and also through the hole in the die-plate and the unperforated portion of the paper, backed up by the plate, pushes another group of the combs along with it. In that manner the notches are aligned under one or more of the bars, and when so aligned, one of the cross-bars will drop down. Up to the present time the motive power has been the human hand. There is no difficulty, however, in applying either electric or other motive power to the actuating device.

You ask the question, Mr. President, whether it was in commercial use. It has been practically adopted by the Postal Telegraph-Cable Company, and a set of instruments, having all the modern improvements which experimental work has determined upon as being desirable, is being installed, and it will then be put into use. It is not in use to-day.

THE PRESIDENT:—As I understand it, the operator at the receiving end turns a crank which operates the carriage and moves the paper along?

MR. VANSIZE:—Yes, sir.

THE PRESIDENT:—And the tape passes through, in the way shown here in this machine?

MR. VANSIZE:—Yes; in the ordinary way of hand-manipulation. Then the operator, when he gets to the end of a line, stops and mechanically returns the paper and spaces, and then turns the crank for another line.

DR. F. B. HERZOG:—I would like to inquire of Mr. Vansize what is the limit of speed at which this electrical device can be operated, and also what is the particular form of typewriter that has been adopted, and the limits of its speed in transcribing from the record?

MR. VANSIZE:—The limit of speed has not been determined in typewriting devices. Of course, there must be a limit beyond

which the keys cannot vibrate. The limit of speed upon the transmitter depends somewhat upon the length of the line, of course. A number of perforators can supply a line with material for transmission; so that cannot be considered a limitation.

DR. HERZOG:—In the statements made concerning the record of the machine in the various tests, it was said that at a certain speed the signals were not received properly. Was that limit reached because the tape was perforated irregularly at that speed, or was it because the typewriting machine would not respond to the tape with sufficient speed? In other words, is the limitation due to the electrical operation of the receiving devices, or to the mechanical characteristics of the particular form of typewriter selected?

MR. VANSIZE:—The limit was due to the action of the perforator at the receiving station. Mr. Murray tells me that at the rate of 100 words a minute the punching magnet has to make 50 perforations per second.

MR. F. V. HENSHAW:—Do I understand that the limit, then, is the punching mechanism? Also, I would like to ask whether there has been any attempt made to devise a typewriter especially for this purpose, or whether you have simply utilized an existing machine? It would appear that if the limit of speed with which this system can be operated is due to the typewriting machine, that a machine could be devised in which the inertia of moving parts is very much less and much lighter, doing away with those heavy bars and keys, and thereby raising the speed perhaps.

MR. VANSIZE:—Mr. Murray has used the Bar Lock typewriter of the ordinary form that is on the market. He has not yet made any endeavor to simplify and lighten the parts of the typewriter, although he has contemplated doing so. The real limitation of speed is in the receiving perforator—the ability which it has to perforate the tape in response to the locally generated impulses; the limit of speed at which the magnet can charge and discharge and get the punch through the paper. It is a question of frequency.

MR. F. V. HENSHAW:—Have you ever tried a laminated magnet in order to increase the speed?

MR. VANSIZE:—The cores are slotted but not laminated.

DR. A. C. CREHORE:—I feel that the Institute should be congratulated upon having a paper of this character presented; I suppose partly because I am interested in the general subject. It seems to me there are many features of simplicity in this that ought to be commended. I refer to this particularly because very little is said in the paper about the transmitting arrangement. I would like to see a sample of the transmitting tape, and if possible, I would like to see the exact shape of the waves which are sent upon the line.

To do the work of cutting a perforated tape with only two

electro magnets, is a neat if not an elegant achievement. It is evident, of course, that the limit of speed must be in that perforating magnet at the receiving end. Of course, if the limit was in the typewriter, another machine could be employed and the tape divided up between the two machines, or among three or four instruments.

I see there is a reed at both the transmitting and the receiving stations, which implies that there must be approximately a synchronism between the two stations. I would like to find out how much variation and how much latitude is permitted between the receiving and transmitting stations in order to have the apparatus work successfully. Would it be possible to have a rotating motor such as is a commercial motor at present? Could the speed easily be regulated within the limits which would be necessary to operate a receiving apparatus of this nature?

Then another point is the shape of the waves or the combination of the waves that can be drawn for two characteristic letters, such as A and B, or C, perhaps; showing how they would be if you used a polarized device and the non-polarized relays in the receiving end. Of course if you refer to the alphabet as given here, it is noticeable that you have got to come down to zero current some time in order to have the magnet become released. And after you have charged the line, I particularly have in mind long-distance lines where the capacity effect is very great, and if you charge the line up to its full extent, and leave it charged for three or four semi-cycles, that charge must be gotten out sufficiently in order to release the magnet, and then another charge put in. The limit of speed on a long line, it seems to me, would be reached in that way; and it would seem, and probably has been found preferable, to use the reverse current for the longer line in order to get the charge out.

Another point that occurred to me was, how much speed has been obtained, working on a local circuit, say, in a room. The speed limit of the apparatus can not exceed on a long line what it is on a short line of that character, and that will probably depend upon the rate which the perforating magnet can operate. I should be pleased to see the action of the perforator.

The use of letters of a uniform length it seems to me is a point of great simplicity in the system, although it is not novel, of course, to this special system. I would also like to inquire whether there is any great difficulty in reading the receiving tape, providing you know the alphabet? Of course if you did not have the words separated and attempted to begin at any point, it would be very difficult, because there is no space between the letters, and you would have to try five times before you would know what you were reading.

Also, I would like to know whether the speed can be easily changed. If the reeds are set to a certain pitch would it take

you a long time to enable you to change to another pitch? Of course, in a Wheatstone apparatus it is very easy to do that, and I do not know that it is a very great point in the commercial use of the apparatus, but I know it is desirable to have a certain standard speed and keep at it. In fact, the English people would like to have a standard speed which they can use uniformly throughout the length and breadth of their island; and of course they will adopt such a speed as they can maintain upon all their lines.

Rather a general question would be in regard to usefulness of words coming out printed, like this, at the rate of 100 per minute, say, and words coming out at some higher rate, printed in Morse characters, which could be translated by an operator in the ordinary method, using a typewriter, and setting it up in print in the same way. If you could receive, say, 300 words by the dot and dash characters, such as in the Wheatstone, and only 100 in this printed way, and your lines were limited—which would you prefer? How would it be commercially determined?

MR. VANSIZE:—Answering the last question first, before it passes from my mind, I would say that that seems to be a commercial question as to whether you prefer to supply lines or to economize on the lines you have. It would seem with the facilities possessed by our principal telegraph companies, that we have lines enough, and it would be preferable to save the time of translation of the received Morse.

The attempt is made, and successfully made, to maintain unison between the *arriving current impulses* and the operation of the local impulse generator. It is not a question of unison between the transmitter and some instrument at the receiving station. It is the question of maintaining unison between the received currents, a sort of co-terminus unison. That is done by devices employing armature transit time.

In regard to the speed on a local circuit, of course we appreciate that as Dr. Crehore says, the limit of speed will undoubtedly be found, and is found in the electro-magnetic perforator used as the receiving instrument of the line. On a local circuit we have done 118 words in a very satisfactory manner, and that with the first instruments, possessing some defects, some slight features which might be changed to improve the general result. But 118 words is what we can safely calculate upon obtaining.

It is not practicable for us to read the received record from the tape. It could be done with instruments, but it cannot be done as a practical Morse operator would read the record from either a chemically prepared tape or an embossed tape.

DR. CREHORE:—Suppose you should displace one unit in your die, how would you then rectify it?

MR. VANSIZE:—We never have been confronted with that difficulty because the instrument does not permit of it. You

step your tape forward one space each time. Of course, if it fails to feed, the thing is thrown out, and I suppose you would have to go back and start over again.

DR. CREHORE:—Suppose the word furnished a sufficient landmark to begin over again, you mean, then you would go back and begin over again; but I suppose there are errors very often in the perforation?

MR. VANSIZE:—Mr. Murray says that he has an apparatus for stepping it ahead one subdivision of a letter, in case the necessity arises for doing that.

THE PRESIDENT:—In this connection I would like to ask how you know where to begin when you feed your tape into the typewriter. You have to start with a certain fixed group of five holes; now, how do you know at which of that continuous row of holes the first group begins?

MR. VANSIZE:—You can go back to the beginning of the message. In telegraphic service the messages are all numbered, and you can start in on your tape anywhere, and you will soon find the beginning of the message, and then you can start in with a retransmission from that point.

THE PRESIDENT:—I do not think you quite understand the question that I asked; it is practically the same that Dr. Crehore asked. There is a continuous row of little guide holes in the tape, of which I understand groups of five correspond to each letter; now, in starting the typewriter, how do you know which of this regular line of holes begins the correct group? Of course the letters will be quite different, depending upon whether you begin the groups with the 1st, 6th, 11th, etc., or the 2d, 7th, 12th, or the 3d, 8th, 13th, and so on.

MR. VANSIZE:—That is true. In the case of the complication of the kind you indicate, which is entirely theoretical, we would go to the beginning of the message, which is indicated by a characteristic starting mark—take, for instance, four or five characters—we would go to that point and start again.

Referring back to Dr. Crehore's question, he asked if the speed could be easily changed. It can be easily and quickly changed. I should think five minutes would be sufficient to change its speed. You would have to change the weight on the reed at both ends if you wanted to change the speed.

The transmitting apparatus is the ordinary Wheatstone transmitter, which we have found it necessary to change to enable both of the so-called prickers to operate coincidentally instead of alternately as is done in the Wheatstone system. That is because the Wheatstone cannot send a succession of the same impulses; it can only print one, three and five, while in Mr. Murray's system it is necessary to be able to transmit one, two, three, four or five, and by moving the "prickers," as the English denominate them, coincidentally, that can be very easily attained.

[COMMUNICATED.]

MR. HOLLON C. SPAULDING:—The writer is much interested in the subject of page-printing telegraph instruments to be treated in the paper by Mr. Vansize to be read at the meeting of the INSTITUTE on to-morrow evening, and regrets exceedingly that he is unable to be present to take part in the verbal discussion thereon. In view, however, of the various statements and references made in the paper, it may be of interest to the members of the INSTITUTE to know that the writer has for some time past been at work on a system of telegraphic communication which bids fair to fulfill the conditions involved in a theoretically perfect system more fully than the devices described by Mr. Vansize, or even indicated by his statements as to the necessities of the case. In the writer's opinion a system of telegraphic communication to be commercially successful should comprise:

FIRST.—A key-board of the ordinary typewriter form, and not requiring the services of a skilled operator.

SECOND.—Immediate and practically instantaneous registering of the desired character at the receiving end of the line.

THIRD.—The registration of an ordinary letter or type character instead of an arbitrary combination of elements which may be translated into one or more ordinary characters.

FOURTH.—The absence of synchronous devices for sending and receiving stations, and of electrical impulses varying in strength, both of which have been found impracticable in commercial use.

In other words, it is my belief that there is a demand for, and incidentally I have succeeded in producing a type printing electro-mechanism corresponding precisely to the ordinary typewriter, except that the key-board and printing mechanism may be separated by any desired distance and connected only by wires suitable for conveying electrical impulses.

Referring to the "forms of punch" shown on page 29, I would say that the writer has had occasion to use something of this kind in another invention, and while it is true that the form of punch indicated by No. 5 is preferable to the others, this could be still further improved by making it hollow, and beveling the teeth so that the end of the punch is practically a saw-section wrapped about an imaginary axis in cylindrical form. A slot should be provided near the cutting end of the tube through which is inserted a wire which will push out the paper disks as cut from the paper, thus keeping the cylindrical cutting end clear at all times.

Boston, January 24th, 1901.

[COMMUNICATED.]

MR. WILLIAM MAVER, JR.:—Whether a thing is considered simple or otherwise often depends upon the point of view. Not long

since, for instance, one of the leading electrical periodicals of London referred to a certain printing telegraph system that had been on exhibition at the Paris Fair, as of "awe inspiring complexity." Being somewhat familiar with the system referred to, I do not agree with this view of it, for, to my mind, it is comparatively simple in its mechanism and operation.

Doubtless one of the chief points of merit of the new telegraph system which has been brought to the attention of the INSTITUTE this evening by the kindness of Mr. Vansize, is its simplicity, for, if it be reliable and practicable in its operation, it must, I think be generally admitted by all who have given this subject any attention, that it is relatively quite simple in construction, and especially, as Mr. Vansize points out, as regards the alphabet employed.

Technically classified, Mr. Murray's system would probably be termed an "Automatic Page Printing Telegraph." The messages to be transmitted by it are prepared beforehand, analogously as in the case of the Wheatstone automatic system. That is, characters set to represent the letters of the message, are perforated on a strip of paper. This perforated paper is caused to send electrical pulsations over a main line, which pulsations operate apparatus at the receiving station, which, in turn, electro-mechanically perforate another strip of paper on a pre-arranged plan. This paper is caused to pass before a set of strips of metal that, in their operation, and, depending upon the position of the perforations in the paper, select a certain letter of a typewriter, in a manner which may perhaps be considered as somewhat similar to that in which the type of a linotype machine find their proper receptacles in the type distributing process.

The unison device employed by Mr. Murray is, I think, ingenious. A somewhat analogous principle for maintaining synchronism between the transmitter and receiver was employed in the Rogers printing telegraph, one of those numerous systems to which Mr. Vansize doubtless refers, which never passed very far beyond the experimental stage. In the Rogers system, as I remember it, a wheel at the receiving station was set to run at a higher rate of speed than the transmitter. A spot of light, or a spark, actuated by the arriving signals was thrown upon the side of the revolving wheel. This spot, so long as synchronism was to be maintained, was kept within a given space on the wheel (quite a little leeway being permissible) by manually applied friction on the wheel. Mr. Murray's method is, of course, more scientific.

It may be noted that Mr. Vansize has not shown, or indicated very fully, the manner in which the messages are received on a page by the Murray system. Provision must, obviously, be made for shifting the paper at the end of each line, etc., and it would, perhaps, be interesting to know whether such provision is made at the sending or receiving end of the line. The table

of alphabets and comparisons of words which Mr. Vansize gives is of much value. Among other things, renewed attention is incidentally drawn, by this table, to the fact that the letter O, of the International Morse alphabet, employing three dashes, or 11 time units (O having a frequency of 8000), could change places to advantage with the letter K, which has a frequency of only 800, and in that alphabet employs but 2 dashes and 1 dot, or 9 time units.

The time units which Mr. Vansize has used for the dots, dashes and spaces are quite fair for machine telegraphy, such, for instance, as the Wheatstone automatic, which employs the Morse alphabet. But it is, I believe, the experience of most telegraphers that rapid Morse senders do not make the pronounced distinction between dots, dashes, and letter and word spaces, that theory requires and the machine system employs. The machine system makes the Morse dash equal to 3 dots; the space between letters equal to 3 dots, and the space between words equal to, say, 6 dots. A Morse operator sending rapidly makes the dash about equal to 2 dots, the letter space equal to 2 dots, and the word space equal to 3 dots. An examination of an embossed tape from a Morse register or recorder will, I believe, show this to be quite nearly the case.

It is perhaps worth noting that the different printing telegraph systems to which Mr. Vansize refers, the Baudot, the Buckingham and the Murray, do not greatly vary as to the message or word-carrying capacity they give to a wire. The Baudot, sending four messages, practically at once, over the wire, transmits a total of about one hundred and thirty-four words per minute. The Buckingham duplexed, about one hundred and sixty, and the Murray, duplexed, it is assumed about the same. A Morse quadruplex system, worked to its full capacity, gives about one hundred and sixty words per minute. The Baudot system, while not sending as many words per minute as the printing systems, does not employ a perforated tape for transmitting.

The further progress of the Murray system will doubtless be watched with much interest.

THE PRESIDENT:—The inventor of this very ingenious and simple system is with us to-night, and I am sure we should all be much pleased to hear from him.

MR. DONALD MURRAY:—I would prefer, gentlemen, to exhibit the mechanism rather than to describe it to you, because I think Mr. Vansize has very ably dealt with the subject, and I do not think I could add anything of interest to what he has said so well. I shall be very happy to show the machine to you after you have finished the discussion, and especially to call your attention to the arrangement by which the typewriter carriage is run back, as I believe one of your members inquired particularly about that feature.

There must be an operator to attend to the receiving of the

message. You cannot have a purely automatic mechanism receiving and distributing the telegrams without supervision. There must be some one in attendance to read the telegrams as they are received, and therefore, while reading the telegrams, the attendant may just as well turn a handle and run the typewriter carriage back.

I have an arrangement for stopping the printer by means of a signal at the end of each line. This break-signal is put in the transmitting tape. When you are playing on the keyboard of the perforator that punches the transmitting tape, and wishing to make a break, you depress a key which inserts a break-signal in the transmitting tape. This break-signal is transmitted and recorded on the receiving tape, and by means of a clutch mechanism the break-signal stops the printer. The typewriter carriage is then run back by the attendant, and the act of running the carriage back starts the machine again. A man has to be there, anyhow, to attend to the receipt of the messages, and he can easily feed the paper into the typewriter and run the carriage back at the end of each line.

MR. GEO. T. HANCHETT:—I am not much of a telegrapher, but it seems to me that the commercial value of this machine will be subject to this condition. We have several systems which are giving satisfactory service; notably the Morse sounder and typewriter and operator. In this machine we have a more complicated typewriter and receiving instrument and also an operator. Now, there must be some gain for this additional complication.

I do not know how many words it is possible for an ordinary typewriter operator to take down in a minute, but I understand that it is possible to send by the Morse system as many words a minute as the ordinary typewriter operator can take down on the machine. I do not know, as I say, how fast a typewriter can be operated, but perhaps our stenographer could tell us.

THE PRESIDENT:—We would be obliged to the stenographer if he would give us some information on that point.

The stenographer stated that seventy-five words per minute was about the highest speed of an expert typewriter operator in writing from continuous dictation.

MR. HANCHETT:—Then, if that is so, it appears that here is a difference in speed between 75 words a minute and whatever this system is capable of—

MR. MURRAY:—If you would allow me to explain. The limit of speed is not in the ability of the receiving typewriter. The receiving typewriter can get up to a speed of ninety words a minute, though that is exceptional. I have had considerable experience with typewriter operators, and I think the average speed is not much more than fifty words a minute; indeed, it is a very good operator who does that. It is the transmitter who is at fault. Transmitting by the Morse key, the average speed

is about 15 words a minute, working by the hour, and 30 words a minute is about the maximum.

MR. HANCHETT:—Then, if 15 words a minute is the average speed of the Morse operator, the gain between that and what is accomplished by this system, which is 100 words a minute, shows what the device accomplishes.

MR. MURRAY:—It is unlikely that the Morse key and sounder will ever be superseded for business requiring quick dispatch. The printing telegraph system described this evening and the others mentioned by Mr. Vansize are big high-power systems like express trains, and they are best suited for handling the mass of telegraphic business between large centers of population. I believe that in time they will each find special fields of usefulness in accordance with their particular capacities. The system described this evening is specially adapted for newspaper work, because the perforated receiving tape can be used to automatically operate a linotype or typesetting machine.

DR. CREHORE:—It is not quite clear to me yet by referring to Figure 4, where the unison diagram is given with the word "Paris," how it is made definite. For instance, take the black line of dots numbered 3 underneath; I understand that that line represents the current impulses coming over the main line. Is that so?

MR. VANSIZE:—Yes, that is right.

DR. CREHORE:—And the black represents the positive current. Then, does the white space immediately following, represent the negative current or no current?

MR. MURRAY:—Either.

DR. CREHORE:—Then would it be possible to divide, say, that first black space which covers two units in the letter "P" into two separate impulses and get the same effect if they were both in the same direction? I mean, could you divide it up in two and not necessarily have it continuous?

MR. VANSIZE:—Yes, sir.

DR. CREHORE:—Or, you could use two successive semi-signs in the same direction, could you?

MR. MURRAY:—I think that would be possible. The real trouble in using the alternating current is to get the time current intervals.

DR. CREHORE:—If the transmitting apparatus has to be as uniform in speed as the reed below vibrates, or very nearly so, how much variation would there be to that variation without interrupting the successful operation of the apparatus?

MR. MURRAY:—That is a question that I could not give you any very definite information about. It will run up as high as five per cent. above the transmitted currents and it will still govern; there is no trouble about that.

THE PRESIDENT:—We have with us to-night Mr. Jones, of the Postal Telegraph-Cable Company, and we should be pleased to hear from him on this subject.

MR. FRANCIS W. JONES:—I did not come here prepared to enter into this discussion. I think the subject has been ably handled by Mr. Vansize. I think possibly the recording of messages upon the typewriter by the received perforated tape might have had a little more elucidation. The drift of the discussion is in the direction of the commercial possibilities of this system, as well as in the electrical and mechanical operation of the system itself. I have been in a position to watch the growth of this infant. The machine you see before you on the table, the combined typewriter with the actuating mechanism, was constructed in Sydney, Australia, by Mr. Murray, in a little workshop that I suppose could easily be placed on one corner of this platform, and I think the machine as it stands here, and as it has been operated, is a very great credit to him.

The system, as has been said, is a very simple one, and it is useless for me to criticize any of the theoretical defects in it because we have simply attached the wires to it between Chicago and New York, and between Boston and New York, and we have the messages here to show what it has done. So it is not for me to say it will not work, when it has worked, and when messages have come through the before-mentioned wires in very clear and nice shape.

It does not seem wise to let this discussion branch off into wild theories. The very best that Morse telegraphers can do, in a day's work, is about thirty words a minute. The simplest of all telegraph systems, outside of the telephone, if you wish to include it, is the Morse system, where a man sits with his hand on his key, his eyes steadily fixed upon the message, the words passing in through his eyes and out through his fingers over the wire into the ear of the receiving operator, and the latter printing it upon a portable printing press—a typewriter. There is no telegraph system that can transmit a message from the sender to his correspondent in so quick a time, except by telephone, as the Morse system operated in this way.

Now, the present plan is to perforate a tape by a keyboard, doing away with the skill necessary for a Morse operator to codify dots and dashes and so send over a wire. It is just simply a keyboard worked the same as the keyboard on a typewriter, and the resulting perforations in the tape are put through an ordinary Wheatstone transmitter, with the modifications that have been so clearly explained by Mr. Vansize, the pricklers working in unison, or simultaneously up to the paper, and there it being determined which one shall go through the perforations. Then, at the receiving end, there is nothing but two relays in line for operating the punching and spacing local magnets, as has been explained. Now, the received tape is placed in the mechanically operated typewriter; Mr. Murray suggests that it is like a mechanical piano; you turn a crank, and it plays the tune, and that tune is the telegraphic message that has been punched at the other end of the line. As you turn this crank by hand or by motor, the

typewriter keys are mechanically actuated, the type striking upon the platen, and so the message is gotten out in page form, the same as on any typewriter. The page moves forward, and when it comes to the end of the line the attendant pushes it back to its original position, and so it goes again, the attendant watching every line to see that there are no mistakes made. Thus every message is under constant surveillance, and is apt to go out to the correspondent in better shape than if a dumb machine actuated by the line currents were to grind it out automatically through a slot, because then no correction would be possible if a mistake were made in a line until after the correspondent got his telegram and sent a message back to the sending station, to say it was all pried, and to please repeat it; but this attendant at the receiving machine sees at once if anything is wrong, and immediately notifies the sending station—probably by the Morse key—the system being quadruplexed—and the sending agent repeats, and so the message is gotten out accurately and without delay.

Another thing is, if you succeed in getting upon your line, say, 100 words perforated at the receiving end, it is not necessary to use only one machine; you can use two, or more. If one machine—as mechanical things do sometimes—gets a little out of order and won't work, you can turn to another machine which is all right, and go ahead; or, you can divide the tape up among two or more persons, if you want to print a lot at a time. That is distinctly a feature of Mr. Murray's system, that the currents coming over the line have not got to actuate a printer; the printing machine is a separate and independent machine, and stands by itself.

I am not prepared to enter into a discussion of the commercial features of this invention at all. It is to stand on its merits entirely. Those people who have their money invested, and who do the telegraph business of the country, will look the matter over carefully and determine whether it is to their interest to employ this machine or not, or to what extent they will employ it. It is certainly natural to suppose that in this new century there must come some improvement; that we cannot keep on putting up wires all the time in order to accommodate the Morse system, and the telegraph managers are watching as closely, and perhaps more closely than anybody else, to find what will serve their purposes best. They certainly do not want to put their money into wires, if, in the end, a little machine will do just as well. Some very clever systems have been devised—Mr. Delany's, and several others that I could name—but the trouble seems to be that while you can get a great deal over a wire, it takes a little time at the start, and a little time at the finish, which handicaps the business, and also that the expense of preparing the tapes and translating the tapes is so much more expensive than by the Morse system, and so much more complicated, and adds so much to the delay of the business, that neither the managers of the telegraph companies nor the public, whose

business is to be transacted, will have anything to do with such systems. That seems to be about the size of the matter, as far as I can get at it. It is not because there is any prejudice at all, for there is no reason for prejudice. The Wheatstone system came to this country in 1880, and I believe there were seven circuits put up, and I think there are not five to-day. If it had been a good thing, and had satisfied the demands of the public, and also had satisfied the managers of the companies in respect to economy, it certainly would have been used more extensively. It does a large number of words per minute, and when duplexed, it is very efficient.

THE PRESIDENT:—I understand Mr. Jones to say that the limit of speed of the Morse system is thirty words a minute for each operator, and if that is quadruplexed, it makes 120 words a minute. So that the difference between a quadruplex Morse system, and a duplex system of this kind would be the difference between 120 and 200. Am I right?

MR. JONES:—Let me explain upon what I based my figures. Between New York and Boston, and some other cities, we have a system in the Postal Telegraph-Cable Company of paying an operator so much a day for his labor. He begins work at eight o'clock in the morning and quits at five-thirty in the evening, with a certain time for luncheon. We put four of those operators on a quadruplex in New York, and there are four in Boston. Those operators get a premium on each message beyond a certain number that they handle in a day. So that they get their regular salary and in addition to that so much per message over and above the number they are expected to do for that salary. Consequently they have quite an incentive to do their very best. Of course the business is ample to furnish all they can do. Now, it has been found that an operator in New York sending to an operator in Boston during that time will do at the rate of 60 to 65 messages per hour, and they average thirty words per message. I have taken thousands of messages out of our files, not only in one year but for years past, at intervals of one, two or three years, and counted them, and they vary between twenty-nine and a fraction and thirty words a message invariably. It is a very singular thing, but that will happen any time you count a bundle of messages indiscriminately. The very highest rate of Morse transmission is about thirty words a minute. Those are the very best operators—the very flower of the flock. Now, if you take the general run of operators, where there isn't piece work, and where they are not inclined to exert themselves to such an extent, where there is no incentive for it, I should think if you got fifteen words per minute on an average, you would be doing very well, indeed.

THE PRESIDENT:—I suggest that if there is no further discussion, the meeting might formally adjourn, and we can then gather around this machine and have Mr. Murray show it to us in operation, as he has kindly offered to do.

[Adjourned.]